JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOLUME 39 DECEMBER 15, 1949 No. 12

BOTANY.—*Cortical tracheids in the African cherry oranges* (Citropsis *species, Rutaceae: Aurantioideae*).[1]

FRANK D. VENNING, University of Miami. (Communicated by WALTER T. SWINGLE.)

The African cherry oranges belong to the genus *Citropsis* and are small-fruited trees or shrubs rather closely related to the genus *Citrus* and even more closely related to *Atalantia* (Swingle and Kellerman, 1914). At the present time 11 species and 1 variety of *Citropsis* are known, ranging across tropical and subtropical Africa from Sierra Leone to Angola on the west coast and from Uganda south to Mozambique in East Africa, as well as in the regions of central Africa lying between (Swingle, 1943). Horticulturists and citrus growers will be interested in the African cherry oranges because of their ability to graft with and support *Citrus*. Gillet's cherry orange, *Citropsis gilletiana*, which makes a sizable tree up to 35 feet high, is the only rootstock that has been used successfully for *Citrus* at the Eala Botanic Garden in the Belgian Congo, where it has been employed on a fairly large scale for all the common species of *Citrus*. It has proved to be immune to the attack of a longicorn beetle very destructive to most *Citrus* rootstocks. Tests of other species of *Citropsis* as *Citrus* rootstocks are also being conducted by the Eala garden (Goossens, 1924; Staner, 1929; Pynaert, 1935; Fawcett, 1936).

Plant anatomists and histologists, no less than horticulturists, will find *Citropsis* an interesting genus because of the abundance of cortical tracheids which accompany or supplement the regular vascular supply in the flowers and fruits. These tracheids, unlike the regular elements of the vascular system, are derived from highly vacuolate cortical parenchyma of the pedicel and receptacle and from the "ground parenchyma" of the floral organs. The individual tracheids usually retain the approximate isodiametric shape of the original parenchyma cell but develop highly lignified reticulate thickenings of the cell wall, after which the protoplast disintegrates. They are of quite general occurrence under many circumstances in plants of the orange subfamily. Their ontogeny has been described in detail in a separate paper (Venning, 1946), and further instances of their occurrence reported for several species of the genus *Citrus* (Venning, 1947).

The present survey determines in which floral organs and under what conditions cortical tracheids occur in all available species of the genus *Citropsis* and discusses their possible functions, together with their application as taxonomic characters.

I express my great indebtedness to Dr. Walter T. Swingle, director of the research project that undertook this study, for providing through his resources much material that would otherwise have been unobtainable. My indebtedness is also expressed to the Science Research Council of the University of Miami, under whose sponsorship the work was conducted.

MATERIALS AND METHODS

Mature flower buds were used for this study. Fresh flowers and flower buds of *Citropsis gilletiana* Swing. and M. Kell. were collected from a plant growing at the U. S. Department of Agriculture's Plant Introduction Garden at Chapman Field, Fla. Similar material of *C. schweinfurthii* (Engl.) Swing. and M. Kell. was obtained from plants growing in the U. S. Department of Agriculture's Citrus greenhouse at Glen

[1] Received July 7, 1949.

Dale, Md. *C. zenkeri* Engler was represented by one flower bud and three small pistils, secured for study from two herbarium sheets of this species in the herbarium of the Museum de Paris by Dr. Walter T. Swingle. Mature flower buds of *C. angolensis* Excell, *C. articulata* (Wild.) Swing. and M. Kell., *C. mirabilis* (A. Chev.) Swing. and M. Kell., *C. latialata* (De Wild.) Swing. and M. Kell., *C. gabunensis* (Engl.) Swing. and M. Kell., *C. le-testui* Pellegrin, and *C. tanzkae* Swing. and M. Kell. were obtained from herbarium specimens of these species by Dr. Walter T. Swingle, who also arranged the loan of the slides of the herbarium material from the Department of Agriculture. These slides were made by Dr. Albert H. Tillson, who was formerly employed as an assistant to Dr. Swingle. Of *Citropsis gabunensis* var. *lacourtiana* (De Wild.) Swing. and M. Kell., no flower buds were available, but a herbarium specimen of a flower from which the petals and stamens had just recently abscissed was secured by Dr. Swingle. The data for *C. gabunensis* var. *lacourtiana* is therefore not complete so far as the tissues of the petals and stamens are concerned, but the data that could be secured from this pistil are included here because it showed differences from the other species. No material of *C. daweana* Swing. and M. Kell., a little-known species, was available.

The fresh material of *C. gilletiana* and *C. schweinfurthii* was fixed in 70 per cent formalin-aceto-alcohol, washed in water, dehydrated with a tertiary butyl alcohol series and imbedded in Fisher Tissuemat.

The herbarium material was restored by the technique developed by Juel (1918) and modified by Dr. Swingle, dehydrated in an ethyl alcohol series, and also imbedded in Tissuemat.

Transverse and longitudinal serial sections of both groups of specimens were made on a rotary microtome at 10, 12, and 15 microns when the material permitted. In several instances only one flower was available from the herbarium material; in these cases only transverse serials were made. The slides were stained with safranin and fast green, and permanently mounted. With the exception of the slides loaned from the U. S. Department of Agriculture, they are permanently filed in the Tropical Histological Research Collection of slides at the University of Miami.

From these flower buds of nearly the same age and same stage of development, the occurrence of cortical tracheids in relation to the main vascular system was determined in all floral organs.

OBSERVATIONS

Location of the cortical tracheids in Citropsis.—As with the other genera of the orange subfamily which develop these structures, cortical tracheids are found in three locations in relation to bundles of the main vascular system: (1) Laterally adjacent to the typical xylem of the true vascular bundles, (2) extending beyond the xylem of the regular vascular bundles, and (3) as independent strands of tissue apart and seemingly independent from the main vascular system.

Only two species, *Citropsis mirabilis* and *C. tanakae*, develop cortical tracheids in the pedicels. In *C. tanzkae* these were isolated strands of tracheids in the upper portion of the pedicellar cortex. *C. mirabilis* also developed isolated strands of tracheids in the upper portion of the pedicel, which often extended unbroken on up into the enlarged

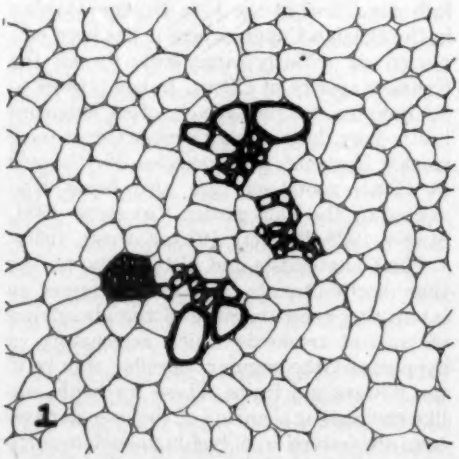


FIG. 1.—Three loose accessory vascular bundles in the receptacle of *Citropsis articulata*, two of which are supplemented by cortical tracheids. Note the pitting of the end wall of one of the tracheids. Cross section. (Serial ST709A.)

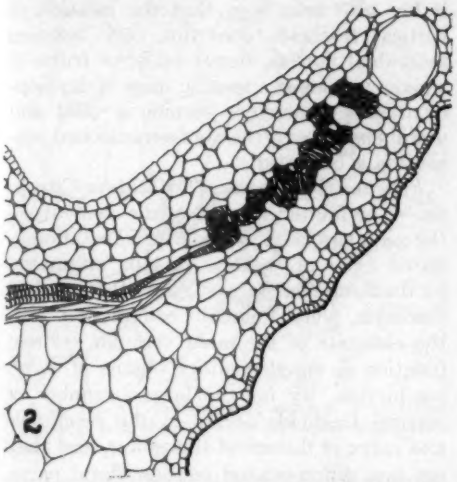


FIG. 2.—Cortical tracheids extending from the termination of a lateral sepal bundle nearly to the tip of the sepal. These tracheids actually form a continuous column, but because of their irregularity the column appears broken in the figure. From *Citropsis mirabilis*, longitudinal section. (Serial ST274B.)

receptacle. In addition, pedicels of this species have loose accessory bundles similar to those described for *Murraya* and *Citrus* (Venning, 1945, 1947), and the xylem of these bundles is often flanked by tracheids derived from cortical parenchyma.

In the receptacle, all the species have some of the regular vascular bundles accompanied by cortical tracheids, and all with the exception of *C. latialata* have the xylem of the vascular bundles extended by cortical tracheids in this region. *Citropsis articulata*, *C. mirabilis*, *C. gilletiana*, and *C. zenkeri* have accessory bundles in the receptacle, and these are flanked by cortical tracheids (Fig. 1). In *C. mirabilis* and *C. zenkeri* the accessory bundles are extended by cortical tracheids. In addition, *Citropsis articulata*, *C. mirabilis*, *C. gilletiana*, *C. gabunensis*, *C. zenkeri*, *C. le-testui*, and *C. tanakae* have independent strands of cortical tracheids in the receptacle, usually about halfway between the epidermis and the stele.

The calyx presents a similar pattern for all species, with both the midrib and lateral sepal bundles accompanied and extended by cortical tracheids (Fig. 2).

With the bundles of the corolla, no cortical tracheids were observed accompanying the vascular bundles, but they were observed as extensions of the bundles in five species, all members of the subgenus *Eucitropsis: C. schweinfurthii*, *C. angolensis*, *C. mirabilis*, *C. gilletiana*, and *C. latialata* (Fig. 3).

The vascular supply to the stamens is not supplemented by cortical tracheids, and none was observed in the male parts of any of the flowers.

The base of the ovary rests on a conspicuous glandular disk, and in *Citropsis articulata* and *C. latialata* a few cortical tracheids were found in this region as independent strands of tissue. In *C. latialata* they occasionally accompanied the main vascular supply to the disk.

In the ovary proper, *Citropsis zenkeri* and *C. tanakae* were the only species to differentiate cortical tracheids. In *C. zenkeri* they consisted of a few independent strands near the top of the ovary, in close proximity to the huge oil glands which develop there. In *C. tanakae* they were found as independent strands in the carpel wall, and a few were seen accompanying the lateral carpel bundles (Fig. 4).

Only *Citropsis articulata* had cortical tracheids in the style; these were in the upper

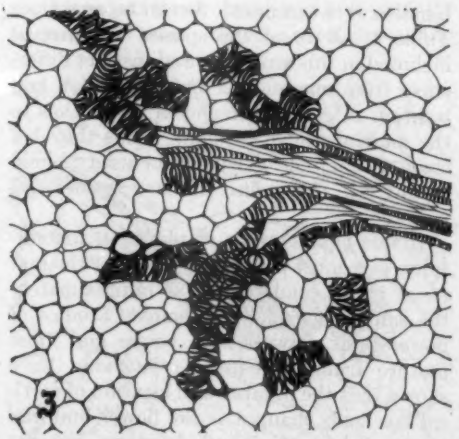


FIG. 3.—Cortical tracheids extending beyond the termination of the true vascular elements in a petal midrib bundle of *Citropsis gilletiana*. Note the general shape and size of these tracheids as compared to the adjoining "ground parenchyma" cells of the petal, and also as compared to the xylem in the vascular bundle. Longitudinal section. (Serial SV423B.)

part near the base of the stigma, and consisted of independent strands, also as an accompaniment to the regular vascular bundles, and as extensions to the minor veins.

Cortical tracheids in the stigma were found in *Citropsis angolensis*, *C. gabunensis* var. *lacourtiana*, and *C. zenkeri*. In *Citropsis angolensis* there were independent strands, as well as extensions of the regular bundles (Figs. 5, 6); *C. gabunensis* var. *lacourtiana* and *C. zenkeri* had no independent strands.

The position of cortical tracheids in the flowers of the species of *Citropsis* studied is presented in tabular form in Table 1 for ready comparison between the species.

DISCUSSION

The use of cortical tracheids in the taxonomy of Citropsis.—As Tillson and Bamford (1938) have described, the members of the genus *Citropsis* all have the floral vascular bundles in an identical arrangement, with the exception of *C. gabunensis*. In this species the dorsal carpel bundles, instead of extending up the style, terminate at the top of the ovary. Tillson and Bamford were only interested in the course or pattern of the floral vascular bundles, and evidently took no notice of the elements from which the bundles were composed. As can be seen from Table 1, all 10 of the species of *Citropsis* included in this study showed distinct differences from one another in the location and position of cortical tracheids in relation to the main vascular elements. Thus they become a character which can be used to help distinguish between similar species or varieties.

If this character be employed taxonomically, care must be taken to see that the material to be compared is at approximately the same stage of development. Studies of flower buds, flowers, and young and more mature fruits of *Citropsis gilletiana* have shown that the number and location of cortical tracheids changes as the flower bud matures, and as the pistil develops. For example, flower buds and flowers of this species have developed no cortical tracheids in the pistil, but as the fruit develops great numbers of cortical tracheids are differentiated in the outer carpel wall. However, it has also been seen that the location of cortical tracheids does not vary between individual flowers, flower buds, or fruits of a given species at a specific stage of development. They therefore become a valid and useful character if the above-mentioned precaution is observed.

Functions of the cortical tracheids in Citropsis.—The limited number of the elements in the main vascular system, which are differentiated from procambial strands originated by the floral meristem, suggests that cortical tracheids, when found in conjunction with the elements of the main vascular system, function as supplementary organs of water conduction. By far the largest number of cortical tracheids occurs in the receptacle and calyx of flowers of this genus, and they are first differentiated in these floral parts. Young flower buds have lateral sepal bundles which contain only a few xylem strands. The lateral sepal bundles arch outward and upward from the stele across the cortex of the receptacle and usually terminate in the lower third of the sepal. There is no procambial strand above the point of termination. Sections of older flower buds or flowers reveal that the number of true xylem elements within the lateral sepal bundles has remained the same, although the sepal may have doubled in size. At this stage of development the xylem of the lateral sepal bundles is invariably flanked with cortical tracheids, from the point of divergence at the stele to their termination in the lower

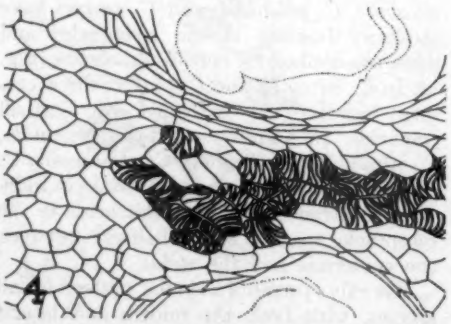


FIG. 4.—Cortical tracheids extending from the top of a lateral carpel bundle up between two oil glands in the stigma of *Citropsis angolensis*. Longitudinal section. (Serial ST273A.)

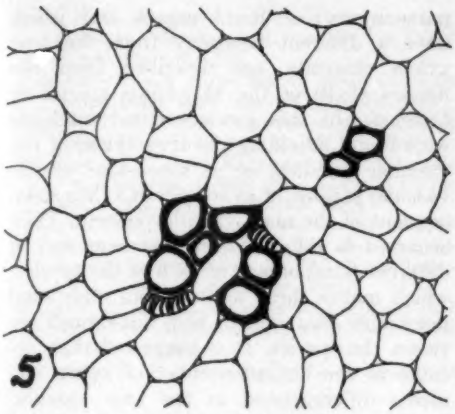


FIG. 5.—An independent strand of cortical tracheids from the stigma of *Citropsis angolensis*. Cross section. (Serial ST273A.)

portion of the sepal. Above the true vascular bundle, long irregular columns of cortical tracheids, developed from the vacuolate "ground parenchyma" of the calyx, extend nearly to the sepal tip.

The sepal midribs on the average contain about 15 xylem elements near the base of the sepals, and this number gradually decreases to five or six elements at the middle of the sepal. Some true xylem elements of the sepal midrib extend into the upper third of the sepals. Here again, as the flower nears the time of blooming and the calyx has reached full size, cortical tracheids are developed in a sort of sheath around the upper portions of the sepal midrib, and also extend from the midrib nearly to the sepal tip.

The calyx of *Citropsis*, as with most aurantioid plants, is persistent after flowering and remains attached to the base of the mature fruits. It reaches its full size during the development of the flower bud and is fully developed when the flower opens. The true vascular elements of the calyx reach their complete differentiation when the flower buds are small. Although there is much secondary xylem derived from cambial activity in the main floral axis as the fruit enlarges, none of the bundles in the calyx or other parts of the flower, other than those of the ovary, develop any secondary elements; and are in effect "closed" bundles, with no cambial activity. The number of xylem and thin-walled elements differentiated within the bundles is entirely dependent on the amount of tissue that was in the procambial strands, which would seem to be insufficient for the increased volume of parenchyma in the mature calyx which must be supplied with adequate water.

Wylie (1939; 1946), who has done a vast amount of work on the organization of vascular to nonvascular tissues in the leaves of several hundred dicotyledons, has concluded that "the distribution of vascular strands in the leaf blade is influenced . . . by problems of transfer through the living tissues lying between the veins." Wylie has further suggested on the basis of his studies that a definite correlation exists between the amount and arrangement of non-vascular to vascular tissues in leaves. In other words, a given volume of a particular kind of parenchyma must have vascular strands at specific spacial intervals for adequate conduction. This concept would seem applicable to floral organs of *Citropsis*, and it seems probable where, for example, in the calyx only a limited quantity of vascular tissue of uncertain length is differentiated, that the "limit of correlation" is exceeded as the parenchymatous cells of the calyx continue to divide and expand, without the accompanying development of more vascular tissue. Hence, as the proportion of non-vascular to vascular tissue becomes too great, the

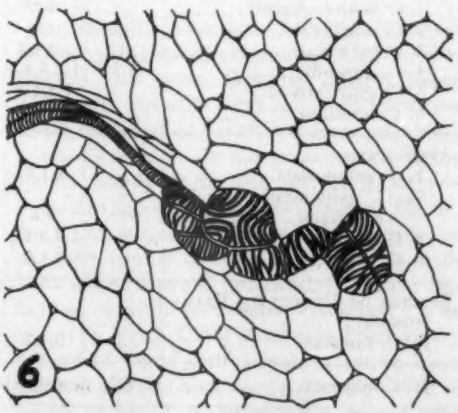


FIG. 6.—Cortical tracheids extending beyond a branch of a lateral carpel bundle in the ovary of *Citropsis tanakae*. Longitudinal section. (Serial ST226A.)

"ground parenchyma" is quickly differentiated into tracheids adjoining and extending the vascular bundles, and which to all appearances are capable of water conduction. It may also be significant that other genera in this subfamily which have large and abundant vascular bundles in relatively small floral organs, such as the genus *Severinia*, have never been observed to differentiate tracheids of this nature.

The independent groups or strands of cortical tracheids are less easily explained. These cells are not in any sense sclerides or stone cells, for they are identical to those associated with the regular vascular tissue, and have reticulate lignified bands on the walls; sometimes the end walls possess numerous simple pits instead of reticulate striations; this condition was also frequently seen for those accompanying the vascular strands. The cells, when fully differentiated, are clear and show no trace of cell contents. Such independent strands or groups of tracheids may serve as water storage tissue.

SUMMARY

Cortical tracheids, which develop from vacuolate cortical parenchyma, or "ground parenchyma" of floral organs and which have a different ontogeny from the true xylem elements, are described from the flowers of 10 of the 11 known species of *Citropsis*. In this genus cortical tracheids were found adjoining the true xylem of the vascular bundles, or as extensions of the vascular supply, or as strands of xylem independent of the main vascular system. They occurred in different circumstances and in different floral organs in each of the species, which makes them useful as an additional taxonomic character to help distinguish between the species. It is suggested that because of the limited number of xylem elements differentiated in the true vascular bundles, and the limited length of many of the vascular bundles, the cortical tracheids, when associated with the regular vascular supply, function in a water-conducting capacity.

LITERATURE CITED

FAWCETT, H. S. *Citrus diseases and their control*, ed. 2. New York and London, 1936.

GOOSSENS, V. *Note sur le* Limonia poggei (Engl.) *var.* latialata *de Wild. employé pour la greffe de l'oranger au Jardin Botanique d'Eala*. Congo Belge Bull. Agr. **15**: 157–162. 1924.

TABLE 1.—DISTRIBUTION OF CORTICAL TRACHEIDS IN THE GENUS CITROPSIS

Species	Pedicel	Receptacle	Calyx	Corolla	Disk	Ovary	Style	Stigma
EUCITROPSIS:								
1. C. schweinfurthii		4,5	4,5	5				
2. C. angolensis		4,5	4,5	5				3,5
3. C. articulata		1,3,4,5	4,5		3		3,4,5	
4. C. mirabilis	1,3	1,2,3,4,5	4,5	5				
5. C. gilletiana		1,3,4,5	4,5	5				
6. C. latialata		4	4,5	5	3,4			
AFROCITRUS:								
7. C. gabunensis		3,4,5	4,5					
7a. C. gabunensis var. lacourtiana		4,5	4,5					5
8. C. zenkeri		1,2,3,4,5	4,5			3		5
9. C. le-testui		3,4,5	4,5					
SPECIES OF UNCERTAIN RELATIONSHIP:								
10. C. tanakae	3	3,4,5	4,5			3,4		
11. C. daweana	(No flowers available)							

KEY: 1: Accompanying the accessory vascular bundles.
2: Extending beyond the xylem of the accessory vascular bundles.
3: Independent strands of tissue.
4: Accompanying the regular vascular bundles.
5: Extending beyond the xylem of the regular vascular bundles.

JUEL, H. O. *Beiträge zur Blütenanatomie und zur Systematik der Rosaceen*. Svenska Vet.-Akad. Handl. **58**: 1–81. 1918.

PYNAERT, L. *Les aurantiées du genre* Citropsis. Congo Belge Bull. Agr. **26**: 305–314. 1935.

STANER, P. *Maladies du citrus au Congo Belge*. Congo Belge Bull. Agr. **20**: 364–373. 1929.

SWINGLE, W. T., and KELLERMAN, M. Citropsis, *a new tropical African genus allied to* Citrus. Journ. Agr. Res. **1**: 419–436. 1914.

———. *The botany of* Citrus *and its wild relatives of the orange subfamily (family Rutaceae, subfamily Aurantioideae). In* The Citrus Industry **1**: Chap. 4. Berkeley, 1943.

TILLSON, A. H., and BAMFORD R. *The floral anatomy of the Aurantioideae*. Amer. Journ. Bot. **25**: 780–793. 1938.

VENNING, F. D. *Accessory vascular bundles in* Murraya koenigii *(Linn.) Spreng. (Rutaceae: Aurantioideae)*. Journ. Washington Acad. Sci. **35**: 352–356. 1945.

———. *Cortical tracheids: A new vascular element from the orange subfamily (Rutaceae: Aurantioideae)*. Quart. Journ. Florida Acad. Sci. **9**: 107–114. 1946.

———. *Variations of accessory vascularization in four species of* Citrus *and their possible application as new taxonomic characters*. Journ. Washington Acad. Sci. **37**: 210–217. 1947.

WYLIE, R. B. *Relations between tissue organization and vein distribution in dicotyledon leaves*. Amer. Journ. Bot. **26**: 219–225. 1939.

———. *Relations between tissue organization and vascularization in leaves of certain tropical and subtropical dicotyledons*. Amer. Journ. Bot. **33**: 721–726. 1946.

ZOOLOGY.—*Three new species and one new variety of amphipods from the Bay of Fundy.*[1]

CLARENCE R. SHOEMAKER, U. S. National Museum.

While studying the amphipod material from the Bay of Fundy, which has been sent to the United States National Museum for identification by the Biological Board of Canada, I noted three new species and one new variety. These are now being described and the types deposited in the National Museum of Canada, Ottawa, Ontario.

HAUSTORIIDAE

Bathyporeia quoddyensis, n. sp.

Figs. 1, 2

According to the key given by E. Emrys Watkin (*A revision of the amphipod genus* Bathyporeia *Lindström*, Journ. Mar. Biol. Assoc. United Kingdom **23** (1): 234. 1938), for the identification of the species of *Bathyporeia*, this species should be *B. pelagica*. While these animals from Passamaquoddy Bay possess the characters he assigns to *pelagica*, they also possess characters that apparently do not belong to *pelagica*. Believing that the characters foreign to *pelagica* are sufficiently pronounced for the establishing of a new species, I am naming it *Bathyporeia quoddyensis*. Females only have been taken.

Female.—The entire animal is heavily pitted, and this pitting can be easily seen when the animal is stained with a dark stain. Eye small, light reddish brown in alcohol, and consisting of about six facets. Antenna 1, first peduncular joint distally rounding, three closely set spinules on the upper, outer, proximal margin and about eight similar spinules continued along the upper margin and around the blunt distal end, a rounding protuberance bearing a few slender spines and three plumose setae at about the center of lower margin, a group of spines distally and three slender spines between the protuberance and end of joint; flagellum consisting of six joints; accessory flagellum without a tuft of setae on its outer margin. Antenna 2, fourth peduncular joint about twice as long as fifth; flagellum shorter than fourth and fifth peduncular joints combined and consisting of seven joints. Mouth parts about normal.

Gnathopod 1, coxal plate centrally constricted and expanded distally, lower and hind margins bearing a few spines; first joint equal in length to the fifth and sixth combined; sixth joint two-thirds the length of the fifth; seventh joint bears a seta proximally on the outer margin and a spinule distally on the inner margin. Gnathopod 2 much as figured by Chevreux and Fage (Fig. 86, gn. 2) for *pelagica*, but there are fewer spinules on lower margin of coxal plate, and the sixth joint is spatulate and not narrowly angular distally as shown in their figure. Peraeopod 1 is as shown by Fig. 2, *C*, the coxal plate bearing very few spines. Coxal plate 4 bears spines on lower margin and lower hind margin. Peraeopod 3 is as shown by Fig. 2, *E*. Peraeopod 4, second joint broadly expanded, with hind margin produced below into a broad rounding lobe. Peraeopod 5 somewhat as figured by Chevreux and Fage (Fig. 86, pr. 7) for *pelagica*, second joint broadly ex-

[1] Received June 6, 1949.

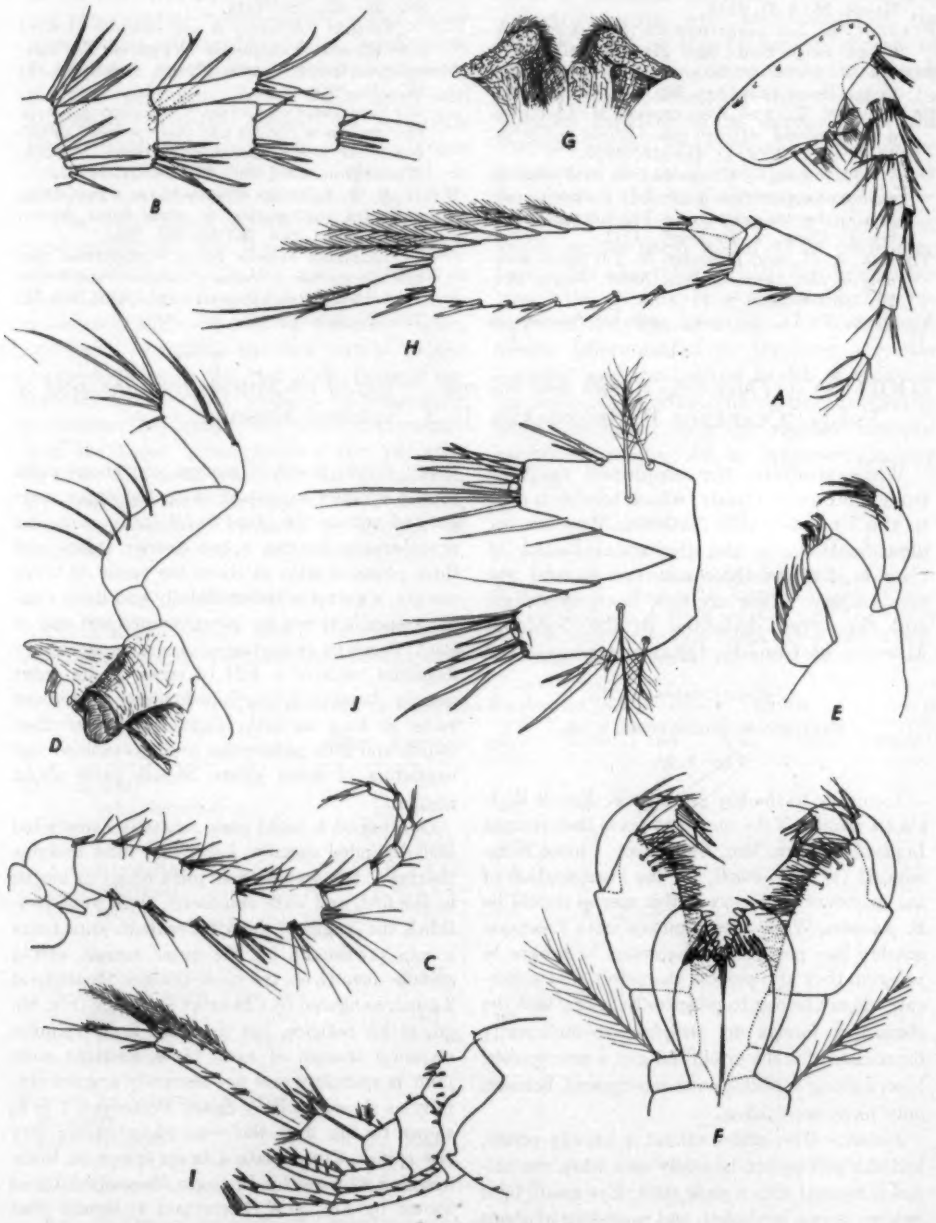


FIG. 1.—*Bathyporeia quoddyensis*, n.sp. Female: *A*, Antenna 1; *B*, antenna 1 enlarged showing the accessory flagellum; *C*, antenna 2; *D*, mandible; *E*, maxilla 1; *F*, maxillipeds; *G*, lower lip; *H*, uropod 3; *I*, hind end of animal; *J*, telson.

panded with the lower hind margin deeply excavate, whereas their figure shows only a small rather shallow excavation.

Uropods 1 and 2 rather long and slender, with spines as shown by Fig. 1, *I*. Uropod 3, outer ramus bearing groups of spines on outer margin and six plumose setae on distal half of inner margin of first joint; second joint with a single plumose seta on inner margin and a group of apical setae; inner ramus with a spinule on inner margin and two or three apically. Telson rather broad, cleft nearly to base, each lobe armed distally with a rather dense group of spines of varying length and thickness, lateral margins with a group of spines at the center, and inner margins bearing a few long slender spines. Each lobe bears on its upper surface a long plumose seta a little proximally of the center and a shorter plumose seta nearer the base.

The third metasome segment produced at the lower posterior corner into a rather prominent tooth above which the margin is markedly convex. The first urosome segment bears the usual dorsal depression and hump; the hump with two setae, posterior to which is a pair of stout backward-curving spines, and posterior to these still another pair of smaller spines. On the lateral side of this segment below the dorsal spines are three backward-curving spines. This segment curves upward from the first uropod forming a very low, flat, convex ridge bearing three spines. Length of female from front of head to end of third uropod from 4.5 to 5 mm.

Type.—A female taken inside West Quoddy Head, Maine, August 13, 1912, surface to 10 fathoms, fine sand, Biol. Board Canada no. 00410.

Besides the type, specimens were taken as follows: 1 specimen taken at Duck Pond, Campobello Island, August 13, 1912, 1–5 fathoms, sand, Biol. Board Canada no. 00408; 1 specimen in Bass River, Coblequid Bay, Minas Basin, September 12, 1921, surface; 1 specimen at Prince Station, no. 17, ¼ mile outside Bunker Island red light, Yarmouth Harbor, Nova Scotia, in 7 fathoms; and 2 specimens inside West Quoddy Head, Maine, August 13, 1912, 5–10 fathoms, Biol. Board Canada no. 00351.

Remarks.—The combination of characters that appears to distinguish this species is as follows: The protuberance on the under surface of the first peduncular joint of the first antenna; the considerable length of the fourth joint of the second antenna; the distally expanded first coxal plate; seventh joint of first gnathopod with the seta on the outer margin proximally placed, and the spinule on the inner margin distally placed; last peraeopod with the second joint greatly expanded and the posterior margin considerably excavated below; first urosome segment with both dorsal and lateral spines; telson with spines on the inner margins of the lobes, and the dorsal plumose setae placed proximally to groups of lateral spines.

The present records are the first for the occurrence of the genus *Bathyporeia* in America.

STENOTHOIDAE

Metopella angusta, n. sp.

Fig. 3

Description of female.—Head with lateral lobes acute. Eyes small, round, and yellowish brown in alcohol. Antenna 1 slightly shorter than 2; peduncular joints decreasing consecutively in length and thickness; flagellum shorter than peduncle and composed of about seven joints. Antenna 2, fourth and fifth joints about equal in length; flagellum shorter than peduncle and composed of about seven joints. Mandible, cutting edge toothed, accessory plate finely toothed; spine row with five or six spines; palp very short, 3-jointed, third joint very short. Maxilla 1, inner plate bearing one distal spinule; outer plate armed with six spine teeth; palp 1-jointed and armed distally with teeth and setae. Maxilla 2, inner plate short and bearing five spines; outer plate with nine spines. Maxillipeds, inner plates rather prominent and united for nearly their entire length; outer plates very short and bearing five spines on inner margin; third joint of palp longest.

Side plate 2 twice as deep as wide, front margin very convex, hind margin nearly straight and bearing several short spines. Side plate 3 more than twice as deep as wide with sides slightly converging distally and hind margin bearing about eight short spines. Side plate 4 very nearly as deep as wide with front margin nearly straight. Gnathopod 1 simple, sixth joint very slightly longer than fifth and bearing about six slender spines on hind margin, which is very finely serrulate. Gnathopod 2 much stouter than 1; second joint longer than fifth and sixth combined; sixth joint with very oblique straight palm, which is very finely serrulate throughout, defined by a short slender tooth and two stout spines.

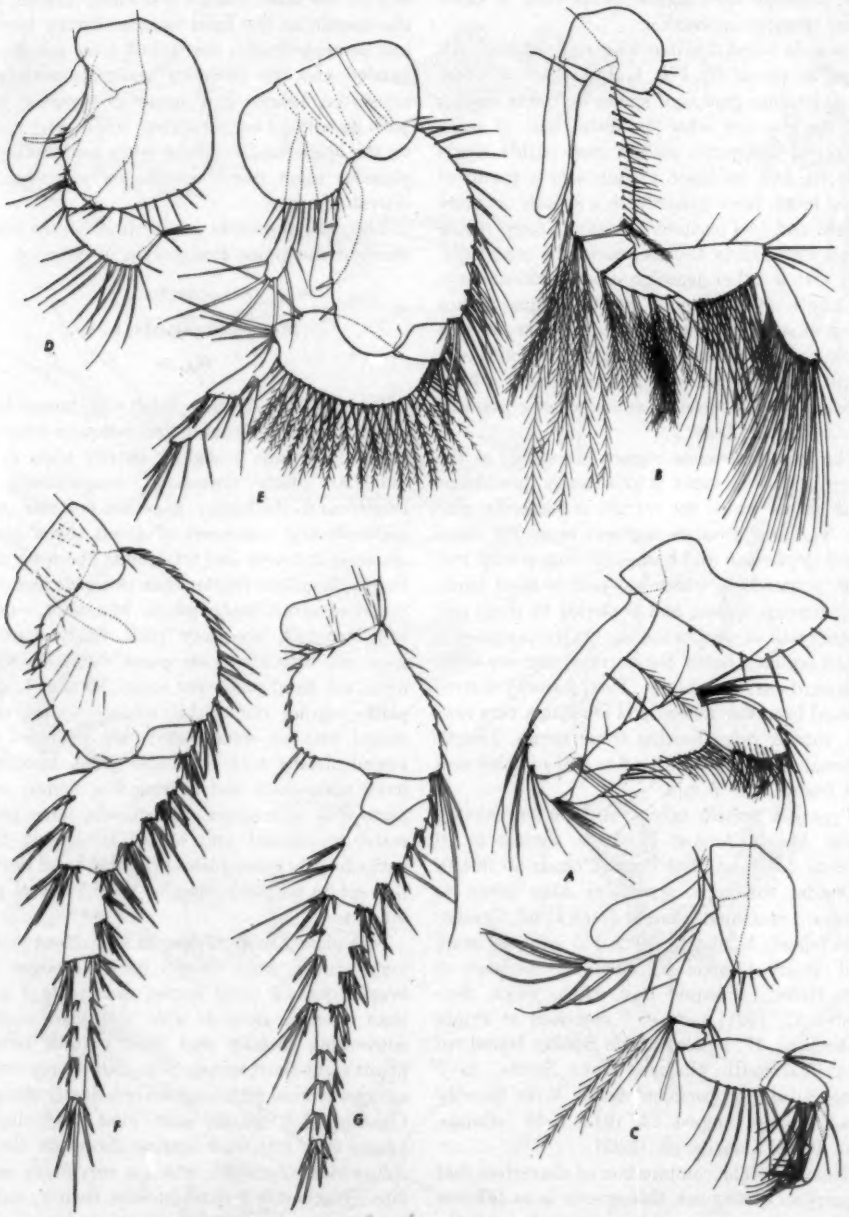


FIG. 2.—*Bathyporeia quoddyensis*, n.sp. Female: *A*, Gnathopod 1; *B*, gnathopod 2; *C*, peraeopod 1; *D*, peraeopod 2; *E*, peraeopod 3; *F*, peraeopod 4; *G*, peraeopod 5.

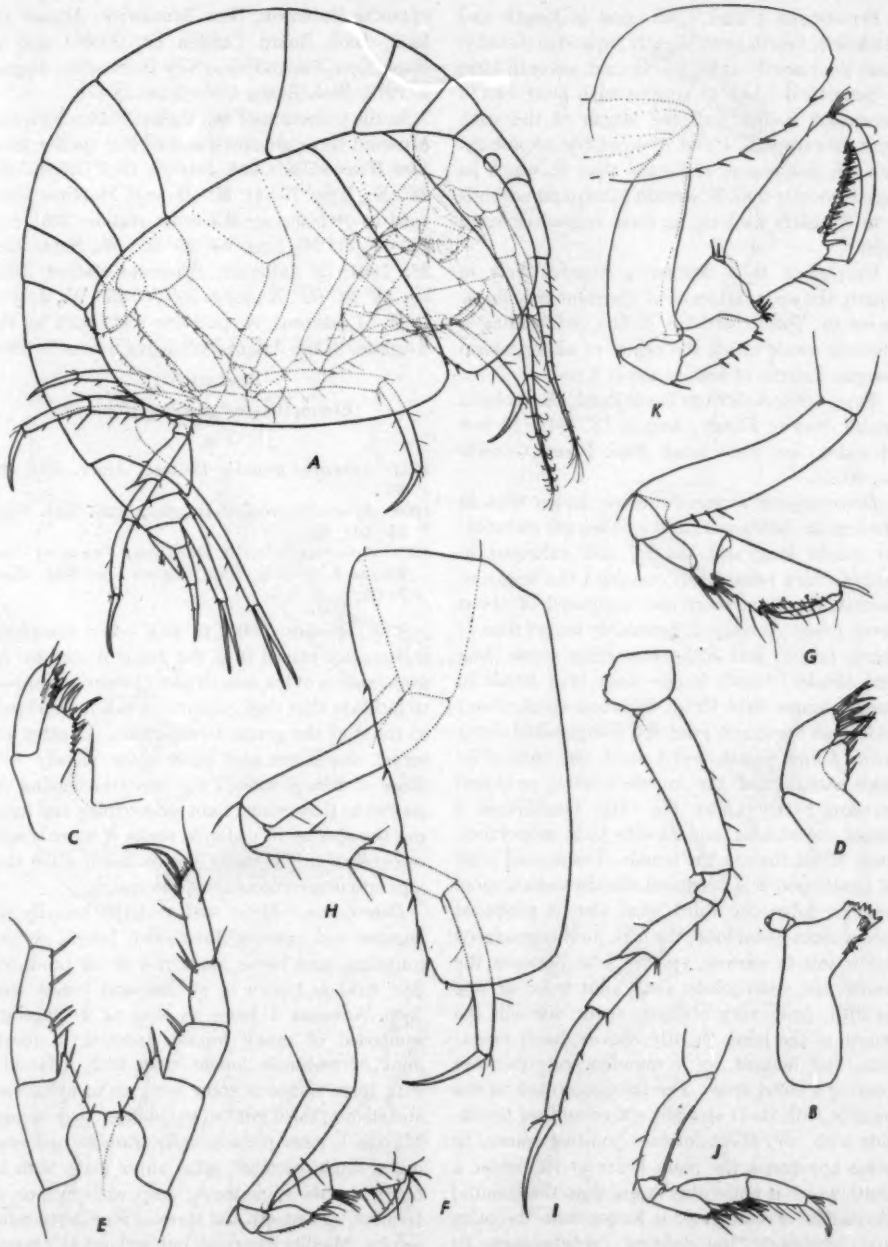


FIG. 3.—*Metopella angusta*, n.sp. Female: *A*, Entire animal; *B*, mandible; *C*, maxilla 1; *D*, maxilla 2; *E*, maxillipeds; *F*, gnathopod 1; *G*, gnathopod 2; *H*, peraeopod 1; *I*, peraeopod 5. Male: *J*, Gnathopod 1; *K*, gnathopod 2.

Peraeopods 1 and 2 subequal in length and thickness; fourth joint slightly expanded distally; sixth joint nearly as long as second; seventh joint in peraeopod 1 half as long as sixth joint, but in peraeopod 2 over half the length of the sixth joint. Peraeopods 4 and 5, second joint not expanded; peraeopod 4 shorter than 5, which in turn is shorter than 3; seventh joint of peraeopods 3 to 5 nearly as long as their respective sixth joint.

Uropods 1 to 3 decreasing consecutively in length, the upper edges of all the rami very finely serrulate. Telson without spines but bearing a plumose setule about the center of either lateral margin. Length of female about 3 mm.

Type.—A female from Duck Pond, Campobello Island, Bay of Fundy, August 13, 1912, 10 feet of water, fine clear sand, Biol. Board Canada no. 00516.

Description of male.—Antennae longer than in the female. Antenna 1, first and second peduncular joints long and slender and subequal in length; third joint about one-third the length of second; flagellum short and composed of about seven joints. Antenna 2, noticeably longer than 1; third, fourth, and fifth peduncular joints long and slender; fourth longer than fifth which in turn is longer than third; flagellum short, about as long as the fourth joint and composed of about seven joints. Gnathopod 1 much like that of female except that the fourth joint is produced forward partly under the fifth. Gnathopod 2 larger and stouter, and its side plate proportionately wider than in the female. The second joint of gnathopod 2 is produced distally into a short anterior lobe; the third joint also is produced into a short distal lobe; the fifth joint is produced below into a narrow, spinose lobe between the fourth and sixth joints; sixth joint twice as long as fifth, palm very oblique, about one-half the length of the joint, slightly convex, finely crenulate, and defined by a rounding protuberance bearing a stout spine. The palm is armed on the outside with short straight spines and on the inside with very short forward-pointing spines. In some specimens the palm bears at its center a tooth which is noticeably larger than the crenulations. The seventh joint is longer than the palm and reaches to the defining protuberance. In other characters the male agrees quite closely with the female. Length of male 3.5 to 4 mm.

Beside the type locality, Campobello Island, this species has been taken in the St. Croix River opposite Robinson, New Brunswick, August 10, 1912, Biol. Board Canada no. 00508; and at Niger Reef, St. Andrews, New Brunswick, August 6, 1912, Biol. Board Canada no. 00478.

In the collection of the United States National Museum there are specimens of this species from *Fish Hawk* station 918, July 16, 1881 (lat. 40° 20′ 24″ N., long. 70° 41′ 30″ W.) off Marthas Vineyard in 44 fathoms; *Albatross* station 2261, lat. 40° 04′ 00″ N., long. 69° 29′ 30″ W., September 28, 1884, 58 fathoms; *Albatross* station 2497, lat. 45° 04′ 00″ N., long. 59° 36′ 45″ W., July 6, 1885, 57 fathoms. A specimen was taken by the *Albatross* in the Atlantic off Nova Scotia in 1885.

PLEUSTIDAE

Stenopleustes gracilis (Holmes)

Fig. 4

1903. *Apherusa gracilis* Holmes, Amer. Nat. **37:** 287.
1905. *Apherusa gracilis* Holmes, Bull. Bur. Fish. **24:** 495, fig.
1905. *Apherusa gracilis* Rathbun, *Fauna of New England*, 5, Orig. Pap. Boston Soc. Nat. Hist. **7:** 65.

S. J. Holmes (1905, p. 495) when describing this species placed it in the genus *Apherusa*. An examination of the mouth parts,however, appears to indicate that they conform m uch more closely to those of the genus *Stenopleustes*. As other external characters also agree quite closely with those of *Stenopleustes*, I am here transferring the species to that genus. I am redescribing and figuring the species in order to make it more easily recognizable. The sexes are so much alike that separate descriptions are unnecessary.

Description.—Head with rostrum broadly triangular and curving downward; lateral corners rounding, and lower angle not at all produced. Eye reddish brown in alcohol and longer than deep. Antenna 1 twice as long as 2; flagellum composed of many joints. Antenna 2, fourth joint of peduncle longer than fifth. Mandible with three spines in spine row; molar cylindrical and strong; third joint of palp longer than second. Maxilla 1, inner plate broadly truncate and bearing a single plumose seta; outer plate with six finely serrate spine-teeth; palp with five or six terminal spine teeth and three or four subterminal setules. Maxilla 2 normal, but without any prominent setae on inner margin of inner plate. Maxillipeds, inner plate rather short and broad with two terminal spinules and two low blunt teeth; outer plate without marginal spine teeth, but bearing a

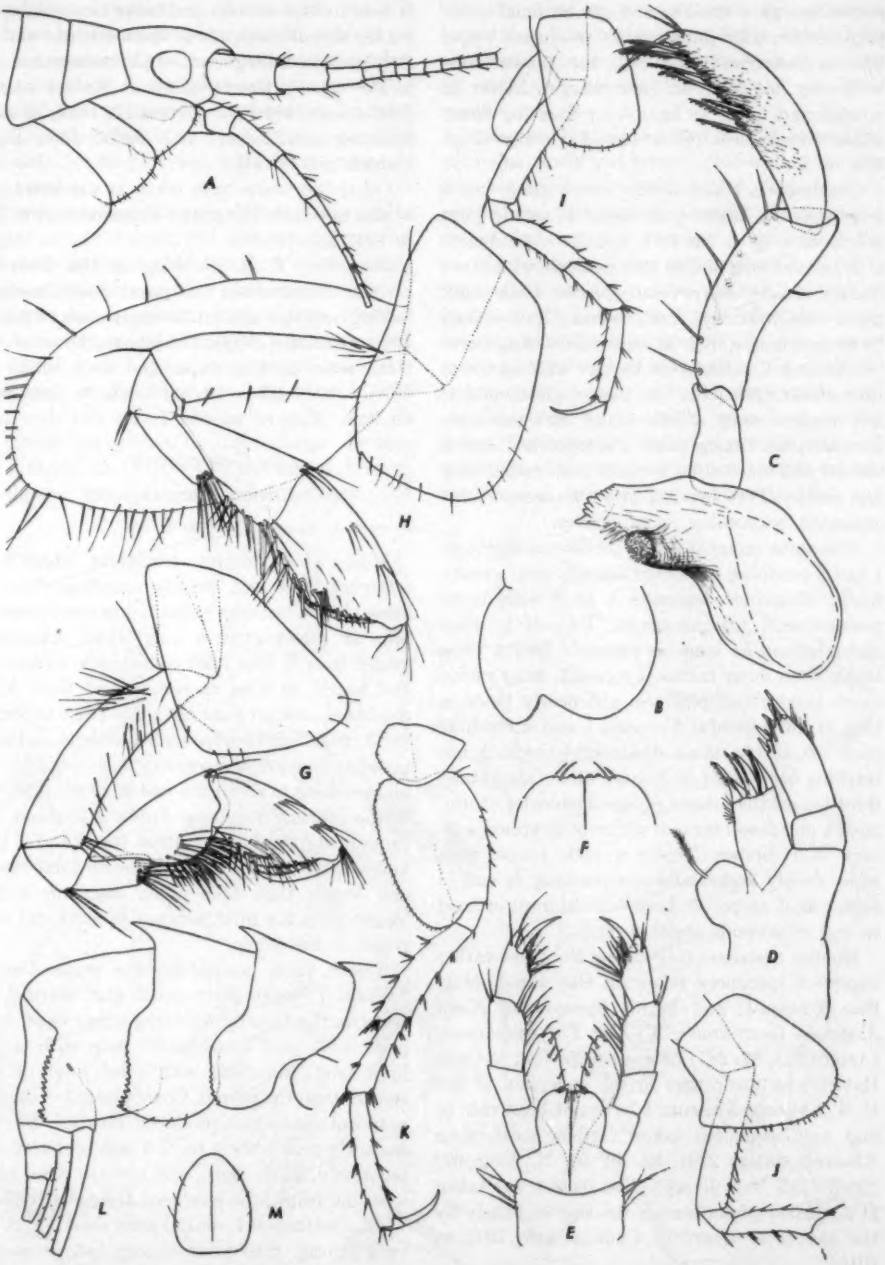


FIG. 4.—*Stenopleustes gracilis* (Holmes). Female: *A*, Front end of animal; *B*, upper lip; *C*, mandible; *D*, maxilla 1; *E*, maxillipeds; *F*, distal ends of the inner plates of maxillipeds; *G*, gnathopod 1; *H*, gnathopod 2; *I*, peraeopod 1; *J*, peraeopod 2; *K*, peraeopod 5; *L*, hind end of animal; *M*, telson.

few submarginal spinules and one terminal spine; palp slender, third joint apically produced. Upper lip unsymmetrically bilobed, the smaller lobe with very fine teeth on inner margin. Lower lip normal and much as figured by Sars for *Stenopleustes malmgreni* (*Crustacea of Norway* **1:** pl. 125, 1, 2).

Gnathopods 1 and 2 very much alike, but 2 somewhat the larger. Gnathopod 1, second joint nearly as long as the fifth and sixth combined; fifth joint as long and as wide as sixth, with lower margin broadly convex and spinose; sixth joint, palm evenly convex, finely serrate, and defined by several long spines; seventh joint fitting palm. Gnathopod 2, fifth joint shorter and narrower than sixth; sixth joint like that of gnathopod 1, but proportionally a little longer and narrower; seventh joint fitting palm. Peraeopods 1 and 2 slender and much alike, seventh joint rather long and slender. Peraeopods 3 to 5 with second joint expanded, succeeding joints slender.

Mesosome segment 7 and metasome segments 1 and 2 produced backward dorsally into a sharp tooth. Metasome segments 1 to 3 with lower posterolateral margin serrate. Uropod 1, inner ramus about as long as peduncle and a little longer than outer ramus. Uropod 2, inner ramus much longer than peduncle and nearly twice as long as outer ramus. Uropods 1 and 2 reaching back about the same distance. Uropod 3 not reaching back as far as 2, inner ramus about one-third longer than outer ramus. Peduncles of uropods 1 and 2 and rami of all uropods armed with very short spines. Telson a little longer than wide, deeply keeled and not reaching to end of peduncle of uropod 3. Length from front of head to end of uropods about 6 mm.

Holmes described this species from two rather imperfect specimens taken off Gay Head, Marthas Vineyard; and in his *Synopsis of North American invertebrates, XVIII: The Amphipoda* (Amer. Nat. **37:** 287) he gives Cape Cod to Cape Hatteras as the range. In the collection of the U. S. National Museum I have not been able to find any specimens taken farther south than *Albatross* station 2261, lat. 40° 04′ N., long. 69° 29′ W. (off New Jersey). The species was taken at a number of stations in the Bay of Fundy by the Biological Board of Canada from 1912 to 1916.

Stenopleustes gracilis inermis, n. var.

This variety is like the typical form except that it is somewhat smaller and lacks the dorsal teeth on the seventh segment of the mesosome and the first and second segments of the metasome.

The type, a female, taken at Wolves Islands, Passamaquoddy Bay, August 17, 1912, 20 to 30 fathoms, sand, mud, and shells, Biol. Board Canada no. 00444.

Other specimens were taken in the lower part of the St. Croix River and Passamaquoddy Bay in 1912 and 1913.

Remarks.—T. R. Stebbing in *Das Tierreich*, p. 309, characterizes the genus *Stenopleustes* as having only one seta on the inner plate of maxilla 1. *Stenopleustes eldingi* Gurjanova, however, has three setae on this plate, and so it seems the definition should be altered to one to three setae on inner plate of maxilla 1.

COROPHIIDAE

Unciola obliquua, n. sp.

Fig. 5

Male.—Head, rostrum triangular, lateral lobes not very large and distally rounding. Eyes on lateral lobes, but very indistinct as specimens had been in preservative a long while. Antenna 1 longer than 2; first joint of peduncle quite stout and nearly as long as second and third joints combined; second joint not quite twice as long as third; flagellum shorter than peduncle and composed of nine joints; accessory flagellum 1-jointed and reaching to about the middle of the first joint of the primary flagellum. Antenna 2, gland cone prominent; third joint rather stout and a little longer than the fourth joint; fourth joint stouter and longer than fifth joint; flagellum a little longer than the fifth peduncular joint and composed of five joints.

Mouth parts normal for the genus *Unciola*. Maxilla 1, inner plate small and bearing two setae on the broadly rounding upper edge; outer plate with nine spine teeth; palp with second joint long. Mandible with third joint of palp shorter than the second. Coxal plates 1–4 shallow, not contiguous and produced forward, the first narrowly and acutely so, 2–4 less produced consecutively. Fifth, sixth, and seventh coxal plates with the front lobe produced triangularly downward. Gnathopod 1, second joint short, stout, and very strong; fifth joint shorter but as wide as sixth; sixth joint widest distally, palm not very oblique, about as long as hind margin of joint, bearing a slight prominence about the center and

defined by a lobe bearing a stout spine which is preceded by a smaller spine; seventh joint stout and not overlapping palm. Gnathopod 2 slender; fifth joint longer than sixth; sixth joint narrowing distally; palm transverse, very short and defined by a slight lobe bearing a small apical spine; fifth and sixth joints provided with dense groups of long bristles.

Peraeopods 1 and 2 much alike and subequal in length; second, fourth, and fifth joints expanded and these together with the sixth joint bearing long slender spines on their hind margin; seventh joint with two spinules on inner margin. Peraeopod 3, second, fourth, and fifth joints expanded and fourth joint bearing many long slender plumose setae on the front and hind margin; fifth joint with two spines on hind margin; seventh joint with two spinules on inner margin. Peraeopod 4 much like peraeopod 3 but longer; second, fourth, and fifth joints expanded; seventh joint with spinules on inner margin. Peraeopod 5, longer than 4; second joint expanded; fourth joint somewhat expanded; seventh joint nearly as long as sixth and bearing four spinules on inner margin.

Metasome segments 1 and 2 with lower hind corner narrowly and acutely produced backward; segment 3 with lower margin continued obliquely upward and backward to the point of attachment to the first urosome segment, thus lacking the acutely produced lower corner which is usual in the genus *Unciola*. Urosome segment 3 is so short that it is not discernible except ventrally at the attachment of the third uropods. Uropod 1, outer ramus a little over half the length of the peduncle, armed apically with the usual stout spines, and on the outer margin with three long slender spines; inner ramus reduced to a little over half the length of the outer ramus and bearing a single small apical spinule; peduncle rather flat and

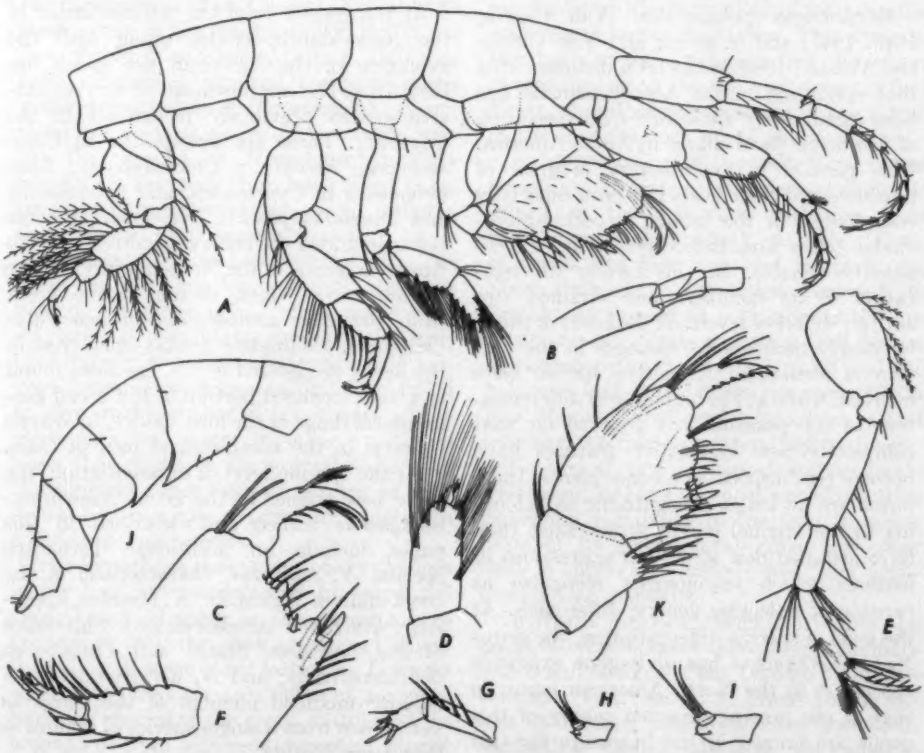


FIG. 5.—*Unciola obliquua*, n.sp. Male: *A*, Front end of animal; *B*, antenna 1 enlarged showing the accessory flagellum; *C*, gnathopod 1; *D*, gnathopod 2; *E*, peraeopod 5; *F*, left uropod 1; *G*, left uropod 2; *H*, left uropod 3; *I*, left uropod 3 enlarged; *J*, hind end of animal. Female: *K*, Gnathopod 1.

broad and bearing a row of long slender spines on outer and inner margin. Uropod 2 bears only the outer ramus which is nearly as long as the peduncle; peduncle with a row of long slender spines on outer margin. Uropod 3 very short, extending very little beyond the telson, and bearing only a vestigial outer ramus armed with three long apical spinules. Telson broader than long, somewhat truncate distally and bearing a seta on either lateral margin. Length of male from front of head to end of uropods 5 mm.

Female.—The female is like the male except that the antennae and first gnathopod are not quite so strong. Gnathopod 1 is much like that of the male, but the palm is more oblique, less sinuous and is not defined by a lobe. Length of female from front of head to end of uropods about 4 mm.

Type.—A male selected from several found in the stomachs of haddocks, nos. 58 and 62, taken by A. W. Needler in the Bay of Fundy.

Five females were taken by the steamer *Speedwell* (no. 141) in Gloucester Harbor, Mass., August 1, 1878, in 8.5 fathoms, and one male was taken by the *Speedwell*, no. 321, lat. 42° 03′ N., long. 70° 15′ W., in Cape Cod Bay, Mass., August 30, 1879, in 29.5 fathoms.

ZOOLOGY.—*Four new species of the acanthocephalan family Neoechinorhynchidae from fresh-water fishes of North America, one representing a new genus.*[1] HARLEY J. VAN CLEAVE, University of Illinois, and RALPH V. BANGHAM, College of Wooster. (Communicated by WALDO L. SCHMITT.)

In previous publications (Van Cleave, 1945, 1947, and in press; and Van Cleave and Manter, 1948) it has been demonstrated that speciation in the Acanthocephala has been significantly associated with speciation of fish hosts, particularly in North America. This parallel in evolutionary progress of parasites and their hosts has been especially conspicuous in the family Neoechinorhynchidae (class Eoacanthocephala, order Neoacanthocephala). In this family diversification of its members has attained two entirely different levels. At the lower of these, by purely quantitative changes in the pattern of structure, distinctive species have evolved, while at the higher level differentiation of the parasites has gone so far that completely new qualitative features have become established. As a consequence, these forms are no longer recognizable as belonging to the original parent genus, since they have attained new structural expressions in features which taxonomists recognize as capable of reflecting generic differences. At the level of specific differentiation, the genus *Neoechinorhynchus* has undergone explosive speciation in the North American fauna so that at the present time ten species of this genus are known in the literature for this continent and three more are to be added in the present contribution.

[1] Received July 7, 1949.

At the generic level the differentiation of the Neoechinorhynchidae along with the evolution of the American fish fauna has resulted in the establishment of five distinctive genera previously recognized in the literature. These are *Octospinifer* in Catostomidae, *Eocollis* in Centrarchidae, *Atactorhynchus* in *Cyprinodon*, and *Gracilisentis* and *Tanaorhamphus* in *Dorosoma*. To these is herein added the sixth distinctively North American genus of the Neoechinorhynchidae —*Paulisentis*, which occurs in the creek chub, *Semotilus atromaculatus atromaculatus* (Mitchill). *Paulisentis fractus*, genotype of the newly recognized genus, has been found in a very localized portion of the broad geographical range of the host species, in Wayne County, in the north-central part of Ohio.

At the specific level of differentiation, the three new species of the genus *Neoechinorhynchus* named and described in this paper include an additional distinctive species, *N. saginatus*, characteristic of the creek chub in Wisconsin; *N. tumidus*, apparently restricted to ciscoes and whitefishes of the Northern States and Canada as definitive hosts; and *N. doryphorus*, a peculiarly modified member of the genus as yet known from a single species of definitive host from Florida.

With the exception of some of the material of *N. saginatus* collected by J. Fischthal and some of the specimens of *N. tumidus*

taken by other collectors, all the specimens that serve as basis for the new species here described have been collected by Bangham in the course of parasite surveys in Ohio, Florida, and Wisconsin.

It is rather remarkable that within a single host species, the creek chub, both the generic and the specific levels of differentiation of its parasites in the Neoechinorhynchidae have been attained. Each of these species seems to be rather definitely limited in its geographical distribution, and although extensive field studies have been made there is as yet no evidence that the two species ever occur in the same locality. The only other instance of a distinctive North American fish with two distinctive species of Neochinorhynchidae is that of *Dorosoma cepedianum* (LeSueur) with its *Gracilisentis gracilisentis* (Van Cleave) and *Tanaorhamphus longirostris* (Van Cleave). Not only do these occur in the same locality, but it has been shown (Van Cleave, 1916, p. 109) that each occupies a seasonal ecological niche within the intestine of *Dorosoma*. At present there are no facts available to explain why the two species of Neoechinorhynchidae adapted to the creek chub have failed to extend their respective geographical distributions beyond their present limits.

Paulisentis fractus has been found in the creek chub in Ohio but never in any other part of the range of the chub, while *Neoechinorhynchus saginatus* occurs in the same host only in Wisconsin. Extensive field surveys in both Wisconsin and Ohio have failed to give evidence that either species of the chub parasites occurs in other vertebrate hosts that might be the normal hosts with the chub, in either instance serving as accidental host of a species normally adapted to a different host species.

The hypothesis that evolutionary changes in the host are accompanied by correlated evolutionary changes in the parasite here appears to lack the obvious support which it receives in some other instances. It seems self-evident that the two different acanthocephalan species of the creek chub probably originated from different ancestral stocks rather than from a common species which was resident in the intestine of the ancestors of the present day chub throughout its geographical range. Available facts give no conclusive evidence as to the lines of descent of the present day parasites of the chub.

It is very unusual for two such diverse species of Acanthocephala to be established in a single host species in a condition of apparently rather strict host specificity while each occupies but a very restricted portion of the geographical range of that host. One of the most obvious explanations might be that each species of the parasite has as an essential intermediate host some species of arthropod whose geographical distribution is distinctly limited. Yet another possible explanation is that in the case of either or both of the species of parasites the chub may be an incidental or accidental definitive host, while some other species of vertebrate, as yet undiscovered, may be the normal host for the parasite.

Within a single host species clearly different levels of diversification of its acanthocephalan parasites may occur. This observation leads to the conclusion that the extent of modification of the fish host does not find direct, quantitative expression in the extent of the modifications of its parasites.

An appreciation of the wide dispersal of *Semotilus atromaculatus atromaculatus* is gained in the following quotation from Hubbs and Lagler (1941, p. 53): "From Montana and from the Red River of the North drainage to the Gaspé Peninsula in Canada, southward on both sides of the Appalachians to Georgia and other Gulf States, southwesterly to the Ozark Upland and the Arkansas and upper Pesos river systems in New Mexico." Over such a broad expanse of territory the fish encounters highly diversified physical and biological environments which seem to have had no direct effect upon producing variability in the fish. In many parts of its geographical range the creek chub is apparently entirely free from acanthocephalan parasites.

In North America, speciation within the genus *Neoechinorhynchus* has been extremely active and the genus has become highly diversified (Van Cleave, in press) to the extent that many fish hosts have their own distinctive species, although the adaptations between parasite and host often permit of more than a single host species. Similarity in food habits often seems to be more important in expanding host relations than

mere blood relationship of the vertebrate hosts although conditions become pyramided in the expansion of host relations when closely related species of fish have identical food habits. Specific adaptations between some members of the genus *Neoechinorhynchus* and peculiar North American fishes and wide host tolerance of others combine to produce contradictory impressions which introduce many difficulties into the recognition of the species of *Neoechinorhynchus* encountered in surveys of fish parasites. The genus is so distinctive that recogtion at the generic level is easily assured on features of general morphology. However, specific identification is often impossible in field studies and must await detailed measurements and comparisons even when intangible evidences seem to set specimens apart as different from all the species previously recognized.

The authors of the present paper have, on numerous occasions, encountered specimens of Neoechinorhynchidae that could not be identified at once. In preliminary reports, these have often been referred to as *Neoechinorhynchus* sp. (Bangham, 1940, p. 299; 1941, p. 163, 164; 1946, p. 321). Several of these undetermined species have been studied critically along with other unidentified specimens from Canada and from the Eastern United States, and in many instances further field studies have been made specifically to secure additional specimens of the critical material for study. In addition to the distinctive *Paulisentis fractus*, three additional species of *Neoechinorhynchus* are being described in this paper. Several other species remain unnamed and undescribed in the authors' collections, pending the discovery of better or more adequate material to justify their diagnosis.

Paulisentis, n. gen.

Diagnosis.—With the characters of the family Neoechinorhynchidae. Proboscis small, shortly cylindrical, provided with relatively weak hooks arranged, not in perfect circles and longitudinal rows but as six diagonal rows of five hooks each. Body wall relatively thick. Musculature of male bursa poorly developed. Parasitic in the intestine of fresh-water fishes. Development unknown.

Type species: *Paulisentis fractus*, n.sp.

Paulisentis fractus, n. sp.

Figs. 1–5

Description.—With the characters of the genus *Paulisentis*. Body short, very broad, without marked attenuation at either extremity, terminating bluntly (Figs. 1, 2). Females (Fig. 1) 2.3 to 4 mm long, with maximum width of about 0.6 to 0.8 mm. Body wall often 0.079 to 0.132 mm in thickness. Proboscis (Figs. 4, 5) 0.093 to 0.105 mm in width and 0.089 to 0.120 mm in length. Males (Fig. 3) 1.4 to 2.86 mm long by 0.410 to 0.620 mm wide. Proboscis but very slightly smaller than in female.

Proboscis hooks (Figs. 4, 5) minute, not conspicuously different in the two sexes; not in perfect transverse and longitudinal rows but in approximately six diagonally spiral lines of five hooks each, making a total of about 30 hooks on the entire proboscis instead of the 18 distinctive of the genus *Neoechinorhynchus*. Hooks near tip of proboscis 24 to 27μ long; in middle region 19 to 27μ; at base 11 to 16μ; the largest hooks from 4 to 6μ in diameter at the bend where thorn and root join. Root processes never conspicuous, poorly defined.

In some males the genital organs (Fig. 3) extend practically the entire length of the trunk; the two testes in broad mutual contact and cement gland (C) broadly joined to the hind testis (T). Anterior testis often touching the posterior end of the proboscis receptacle. Cement gland somewhat shorter than either testis.

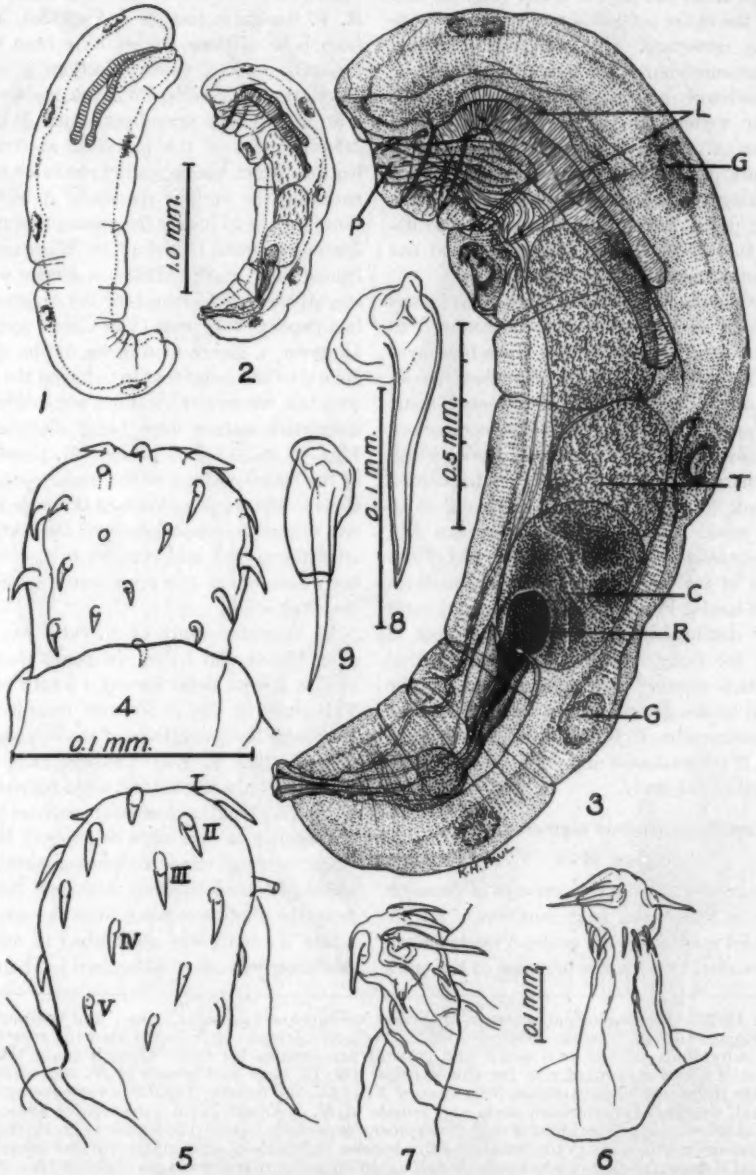
Lemnisci (L), when fully extended, usually reaching to the interval between the second and third dorsal subcuticular giant nuclei. Nuclei of the lemnisci not distinguishable in available material.

Shelled embryos within body cavity of gravid female 35 to 38μ long by 11 to 14μ wide. Development wholly unknown.

Definitive host.—*Semotilus atromaculatus atromaculatus* (Mitchill), the creek chub from streams in Wayne County, Ohio, collected by R. V. Bangham.

Type material.—Holotype male, U.S.N.M. Helm. Coll. no. 37128. Allotype female (VC 3713.1) and series of paratypes representing both sexes in the collection of H. J. Van Cleave, Urbana, Ill., and paratypes in the collection of R. V. Bangham, Wooster, Ohio.

In all the specimens available for this study, at least the base of the proboscis was retracted



FIGS. 1–5.—Morphological details of *Paulisentis fractus*, n.g. and sp.: 1, 2, Outline drawings showing characteristic body form of paratype female (1) and holotype male (2) and relative size and shape of the two sexes; 3, analytical study of morphology of holotype male; 4, 5, typical proboscides when dissected from their retracted position within front end of trunk.

FIGS. 6–9.—Morphological details of *Neoechinorhynchus doryphorus*, n.sp.: 6, 7, Proboscis and its attachment to trunk, viewed from opposite lateral surfaces to show disparities in lateral hooks of terminal series; 8, 9, detail showing form and structure of the two highly modified lateral hooks.

within the front end of the trunk (Fig. 3), and in many the entire proboscis was completely obscured by retraction. The delicate hooks could not be measured nor could their arrangement be determined with accuracy in retracted individuals. The writers are particularly indebted to Mrs. Jean A. Ross for skillfully dissecting out the minute proboscis from many of the worms and making stained permanent mounts of the dissected parts. Without these mounts the details of the proboscis and its hooks could not have been determined.

Since the genus *Paulisentis* is monotypic, the comparisons of *P. fractus* must be confined to species of other genera of the Neoechinorhynchidae. The presence of more than three circles of proboscis hooks very distinctively sets it apart from all species of the genera *Neoechinorhynchus*, *Octospinifer*, *Eocollis*, and *Gracilisentis*, which are all characterized by the rigorous imposition of a hook formula invariably involving three circular rows. The genera *Atactorhynchus* and *Tanaorhamphus* are the only North American members of the family having more than three circles of hooks. From *Atactorhynchus*, *P. fractus* is easily distinguishable through differences in form of the body, extent of the male genital organs and number and arrangement of the proboscis hooks. From the two described species of *Tanaorhamphus*, *P. fractus* differs in the shape and size of the proboscis and number of its hooks and shape of the body.

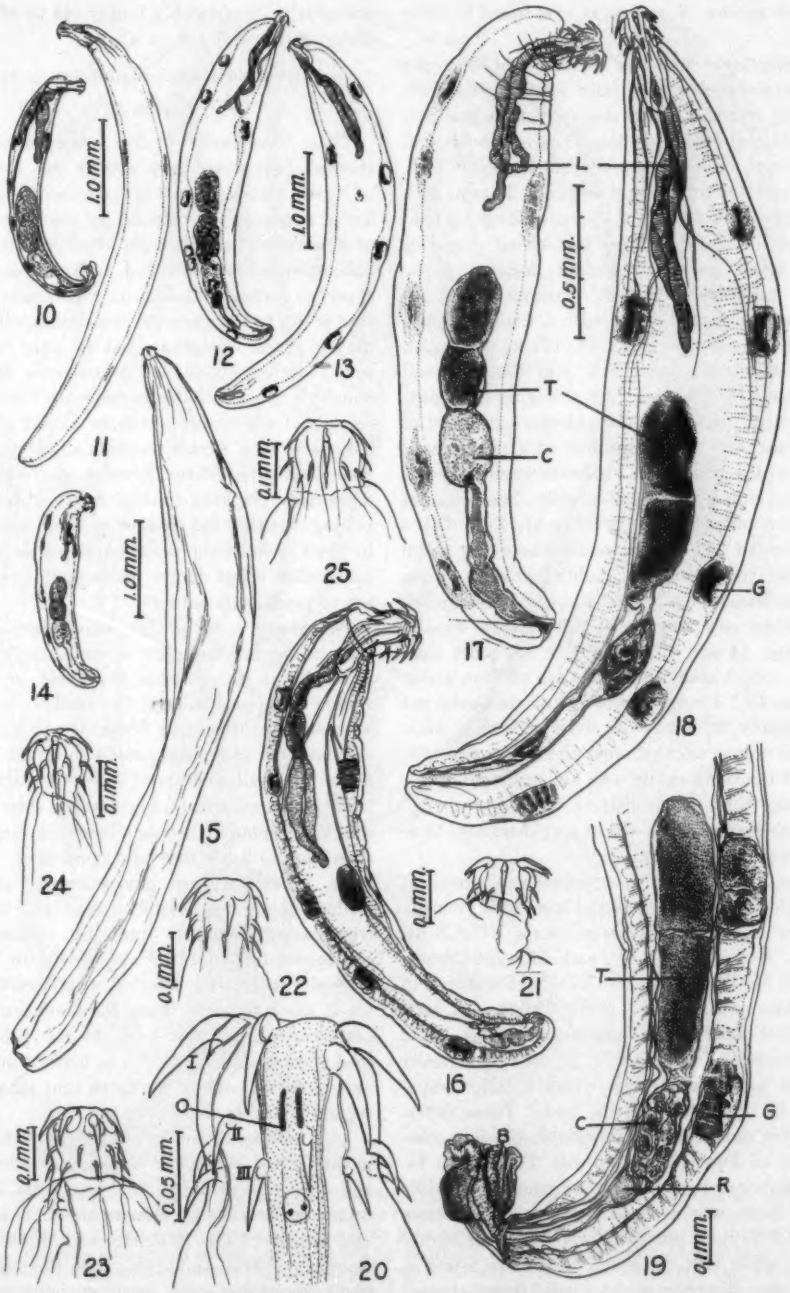
Neoechinorhynchus saginatus, n. sp.

Figs. 12–25

In the course of extensive surveys of parasites of fishes of Wisconsin, large numbers of an undetermined species of the genus *Neoechinorhynchus* were discovered in the intestine of the creek chub (*Semotilus atromaculatus atromaculatus*) by R. V. Bangham and by J. Fischthal. Materials from both of these studies have been available for study and on these collections is based the description of *Neoechinorhynchus saginatus*, n.sp., a form with very prominent sexual dimorphism. Measurements of the proboscis and its hooks, features which are so readily available for differentiating the various species of *Neoechinorhynchus*, seemed to justify the assumption that these specimens from the chub in Wisconsin might belong to *N. rutili* (Müller) a species which has recently been determined for the American fauna in a paper now in press (Van Cleave and Lynch). However, a glance at a series of the specimens gave absolute proof that in reducing the comparisons to a few selected features some differences of distinctive nature were being disregarded (cf. Figs. 10 and 11 with 12 and 13). General shape of the body, position of the proboscis in its relations to the trunk and size of the male reproductive organs in comparison with the body size are all features that add support to the distinctive body sizes of the two sexes in the material from the creek chub.

An extensive study of *N. rutili* has revealed (Van Cleave and Lynch, in press) that females of that species never exceed a length of 10 mm. This limit in size is likewise recorded for the European representatives of the same species by Meyer (1932; p. 172). Consequently, when females in chubs were found often between 15 and 20 mm in length, it seemed obvious that such discrepancy in size adds its support to the distinctive though minor morphological features and specific host relationship. Although the material from the chub was taken from the same regions where *N. rutili* was established in other hosts, the latter was never recognized in chubs nor was

FIGS. 10–25.—Morphological features of *Neoechinorhynchus saginatus*, n.sp., and comparison with general appearance of *N. rutili* (Müller): 10, 11, Male and female of *N. rutili* showing relative size of typical individuals of the two sexes and general proportions for body of each (note that female, Fig. 11, is of about maximum size for this species); 12, 13, male and female of *N. saginatus* showing distinctive difference of body shape from that of *N. rutili*, the female (Fig. 13) a very young immature individual; 14, 15, characteristic male and female of *N. saginatus* from intestine of same specimen of creek chub, showing prominent sexual dimorphism, especially in size, the female (Fig. 15) considerably below average maximum size for females of this species (a female of near maximum size from same host individual if drawn to same scale would be half again longer than entire length of this plate); 16, juvenile female of *N. saginatus* from intestine of a creek chub, before the egg balls have formed; 17, 18, typical males of *N. saginatus* showing topography of genital organs (in Fig. 18 the testes have already begun to break up); 19, posterior extremity of male of *N. saginatus* with copulatory bursa partially extruded; 20, proboscis of female of *N. saginatus* greatly enlarged to show characteristic arrangement of the two elongated and a single spherical nucleus in the distinctively elongated terminal organ of proboscis; 21–25, individual variation in size and appearance of proboscis of *N. saginatus*, all drawings to same scale.



FIGS 10–25.—(See opposite page for explanation).

the new species, *N. saginatus*, ever found in other fishes.

Description.—With the characters of the genus *Neoechinorhynchus*. In fully grown individuals showing extreme sexual dimorphism in size (cf. Figs. 14 and 15). Body more nearly robust than cylindrical, with relatively thick body wall. Females often attaining a length of 20 mm, with a diameter of 1.25 to 2.1 mm in large, gravid females, in the vicinity of the second dorsal or the ventral giant subcuticular nucleus; posteriorly tapering gradually; anterior extremity somewhat enlarged, often with a slightly humpbacked appearance (Figs. 12, 17) in the region where the trunk reduces to join the neck and proboscis. Proboscis usually emerging from near the ventral margin of the anterior extremity of the trunk and rarely standing at a conspicuous angle to the body axis. Proboscis commonly 105 to 119μ long by 79 to 132μ wide. The hooks of the terminal circle usually 58 to 67μ long with a diameter of 16μ at the point where the thorn joins the root. Hooks of middle circle 31 to 38μ long; of basal circle 27 to 32μ long. Males diminutive when compared with fully grown females (cf. Figs. 14 and 15) commonly not more than 8 mm with a maximum diameter of from about 0.7 mm to 1.4 mm. Proboscis and its hooks not appreciably different from those of female. Male genital organs occupy only about the posterior half of the body cavity and are regularly of less diameter than the width of the body cavity. Hard shelled embryos within gravid females 44 to 46μ long by 16 to 20μ wide.

Type host.—*Semotilus atromaculatus atromaculatus* (Mitchill) in streams and lakes of Wisconsin.

Type material.—Holotype male (U.S.N.M. Helm. Coll. no. 37130) and allotype female (U.S.N.M. Helm. Coll. no. 37131). Paratypes in collection of H. J. Van Cleave, Urbana, Ill., and in collection of R. V. Bangham, Wooster, Ohio.

Remarks.—*N. saginatus* is morphologically nearest to *N. rutili*, from which it differs especially in proportions of the body. These differences are most readily appreciable through comparison of Figs. 10 and 11 with Figs. 12 to 14. The proboscis hooks of the terminal and middle series in *N. saginatus* tend to be smaller than those of *N. rutili* but there is so much variability in the latter that some individuals are found in which this difference is not a valid basis for separating the species. The embryos of *N. saginatus* are usually considerably longer (44 to 46μ) than those of *N. rutili* (30 to 40μ).

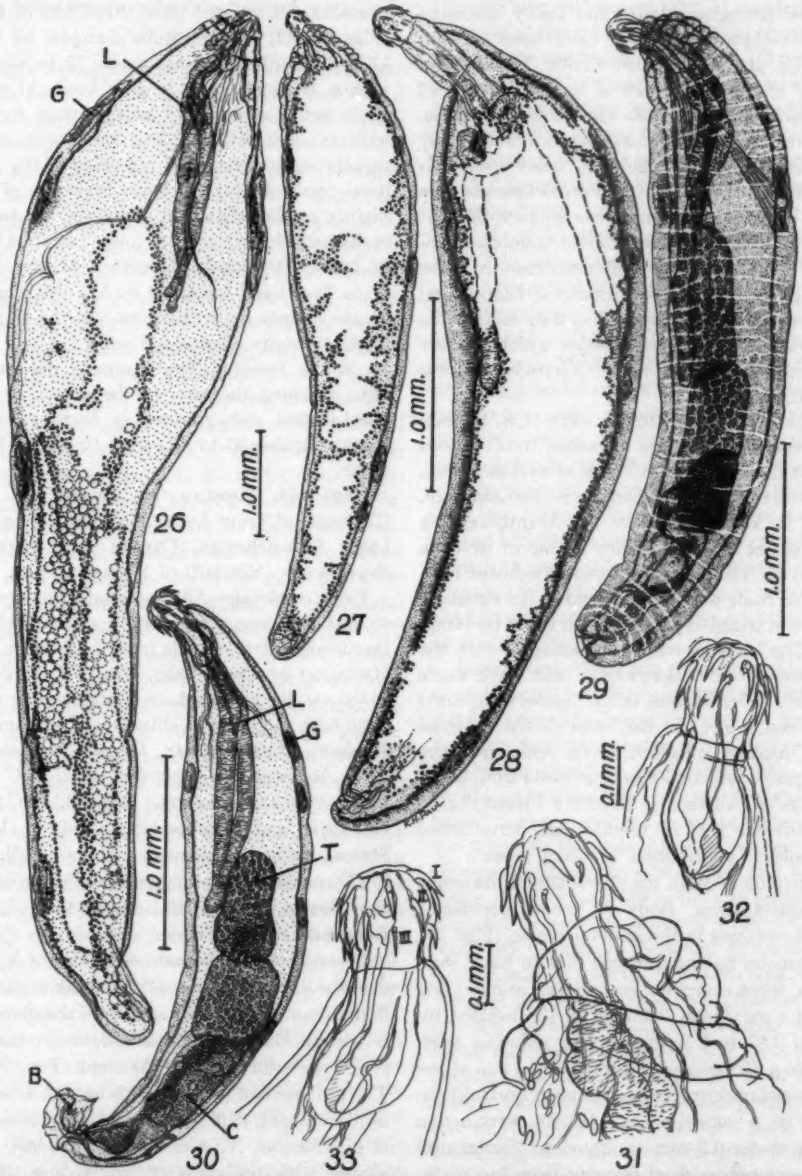
Neoechinorhynchus tumidus, n. sp.

Figs. 26–32

There have been but few instances of Acanthocephala reported from ciscoes and whitefishes of North America. Most of the recorded instances are of apparently accidental infection by species of Acanthocephala common in other fishes of the habitat under consideration. In America, *Echinorhynchus coregoni* Linkins is a common species that seems to have normal association with fishes of the genus *Coregonus*, but in most habitats several other species of fishes seem to serve equally as hosts for this parasite. In Europe, the records of whitefishes similarly consist of a long list of species of Acanthocephala all of which have wide host adaptations. Ciscoes and whitefishes are largely plankton feeders; hence it is not surprising that they fail to show as great consistency in their acanthocephalan parasites as are the fishes that select larger arthropods as food or are of predacious habits.

Parasite surveys have previously demonstrated that heavy infections by worm parasites occur especially in those fishes that feed in shallow waters and particularly in weed beds where intermediate arthropod hosts are brought into intimate and prolonged association with infected fishes. General infection of susceptible arthropod hosts by larval acanthocephalans is thus assured and these same arthropods transmit their parasites back to fishes that feed upon them. In contrast, fishes that are predominantly plankton feeders are not intimately associated with the free-floating plankton organisms, consequently the opportunity for the arthropods to become generally or heavily infected with Acanthocephala is much reduced. Thus the plankton arthropods cannot transmit back to the fishes that feed upon them as heavy or as general infections as are carried back to the fishes that inhabit and regularly feed in shallow waters.

In a number of surveys of fish parasites made in the United States and Canada, the whitefishes and ciscoes have been found free from acanthocephalan parasites peculiar to them (Van Cleave and Mueller, 1934; Bangham and Hunter, 1940; Bangham, 1946). In keeping with the statements made above, in some localities infections with *Leptorhynchoides thecatus* (Linton) have been



FIGS. 26–33.—Morphological features of *Neoechinorhynchus tumidus*, n.sp.: 26–28, Outline drawings of mature paratype females showing characteristic inflation of forepart of trunk and distinctive shape of region where inflated trunk becomes reduced to join neck and proboscis (28) (in all this series the extent of the developing eggs filling the body cavity is shown schematically without attempt to indicate individual eggs and embryos); 29–30, morphological details of paratype males showing individual variation in body shape, Fig. 29 from Waskesin Lake, Saskatchewan, and Fig. 30 from same host species of Trout Lake, Wis.; 31–33, proboscis and its attachment to neck and trunk—Fig. 32 is of holotype female, Figs. 31 and 33 are of paratype individuals.

reported (Bangham, 1941) and heavy infections of *Echinorhynchus coregoni* have been encountered (Bangham and Hunter, 1939). Unpublished records of the occurrence of light infections of *Pomphorhynchus bulbocolli* are likewise available. All three of these are well known and easily recognizable species. Therefore when specimens of a distinctive species of *Neoechinorhynchus* were found in considerable numbers in two different northern localities they aroused immediate interest. A careful study and comparison of these specimens with all known species of Europe and America has demonstrated that they represent a previously unrecognized species which is here described under the name *Neoechinorhynchus tumidus*, n. sp.

In the period from 1928 to 1930, D. S. Rawson made collections of fish parasites from various lakes in the Canadian province of Saskatchewan. He submitted these specimens to the late Prof. Henry B. Ward, who gave the Acanthocephala from ciscoes and whitefishes to one of us (Van Cleave) for identification. Later, specimens from the same hosts were encountered in the extensive surveys of parasites of Wisconsin fishes by Bangham. The latter proved to be identical with the specimens from Saskatchewan and have made possible a fuller analysis of the species than could have been drawn on the basis of the material from Canadian collections alone. Although there are negative records for normal hosts from many localities in Canada and Northern United States, it is probable that *N. tumidus* may have broad geographical distribution in these areas.

Description.—With the characters of the genus *Neoechinorhynchus*. Body of female showing a distinct inflation in the anterior region (Figs. 26, 28). Females having a length of 4 to more than 12 mm, when somewhat compressed in mounting having a maximum diameter in the inflated region of 0.87 to 2.5 mm, rapidly reducing anteriorly to a diameter of about 0.3 to 0.4 mm at the juncture of neck and trunk and posteriorly diminishing to a subcylindrical taillike termination usually under 0.5 mm in diameter. The genital pore commonly a short distance from the posterior extremity (Fig. 26) at the base of a slight postgenital protuberance. Body of males (Figs. 29, 30) shortly cylindrical, lacking anterior inflation characteristic of the females, commonly 3 to 5 mm long with a maximum diameter of 0.7 to 1.5 mm. Neck short, about 40 to 80μ long, an unmodified truncated cone. Proboscis of female (Figs. 31, 32) 172 to 210μ in diameter by 132 to 172μ in length. Terminal hooks 75 to 84μ long with a diameter of 16 to 19μ; hooks of middle circle not conspicuously smaller than those of terminal series, 67 to 79μ, commonly with a slightly sigmoid outward reflection of the point; basal hooks 45 to 53μ long. Proboscis of male slightly smaller than that of female, 158 to 172μ in diameter by 119 to 154μ long. Terminal hooks 69 to 84μ (16–19μ in diameter). Median hooks 67 to 79μ; basal hooks 40 to 53μ. Male genital organs occupy more than one-half the length of the body cavity. Testes and cement glands (Figs. 29, 30) in broad mutual contact; the lemnisci often reaching the level of the posterior testis. Hard-shelled embryos within body cavity of gravid females 36 to 40μ long by 16 to 19μ in width.

Hosts.—In intestine of *Leucichthys artedi* (LeSueur) of Trout Lake, Wis., and of Waskesin Lake, Saskatchewan, Canada, and *Coregonus clupeaformis* (Mitchill) of Waskesin Lake.

Type material.—All material prepared as stained permanent mounts on slides. Holotype female and allotype male from *Leucichthys artedi* (LeSueur) of Trout Lake, Wis. (VC 3812), collected by R. V. Bangham. Paratypes from the same host and same locality as well as from Lake Waskesin, Saskatchewan, Canada, collected by D. S. Rawson in *Leucichthys artedi* (VC 2387) and *Coregonus clupeaformis* (Mitchill) (VC 2390). Holotype and allotype deposited in United States National Museum (Helm. Coll. nos. 37133 and 37134). Paratypes in collection of H. J. Van Cleave, Urbana, Ill., and in that of R. V. Bangham, Wooster, Ohio.

Remarks.—In fully mature females of *N. tumidus*, the anterior region of the trunk is more inflated than in any other species of the genus and is conspicuously distinguishable from the narrowed posterior region of the trunk (Figs. 26–28). The proboscis of *N. tumidus* is smaller than that of *N. crassus* but it is distinctly larger than that of *N. cristatus*, *N. venustus* and *N. rutili*. From species with proboscis of similar size, that of *N. tumidus* is most readily distinguishable by the fact that the hooks of the second series are not conspicuously smaller than those of the terminal series. Usually the hooks of the second series are slightly sigmoidal with the point curved outward away from the proboscis wall.

Neoechinorhynchus doryphorus, n. sp.

Figs. 6-9

When asymmetry in arrangement of the proboscis hooks occurs in the Acanthocephala, it most often finds expression as dorsoventral differentiation of the pattern (Van Cleave, 1941). For the genus *Neoechinorhynchus* most investigators have assumed (Van Cleave, 1939) that radial symmetry is the fixed rule for most species. As early as 1904, Lühe (p. 191) called attention to the fact that the hooks of the so-called terminal circle on the proboscis of *N. rutili* (= *E. clavaeceps*) are actually arranged in two levels, but he was in serious error when he expressed the belief that this constituted a pattern of two circles of three hooks each. Not all species of *Neoechinorhynchus* show this differentiation of the terminal hooks satisfactorily. For *N. emydis* (Leidy), Lincicome (1948) clarified this matter by demonstrating that a single hook on each of the two lateral surfaces of the proboscis is set somewhat posterior to the point of attachment of the two ventral and the two dorsal hooks of the same series. He further emphasized the fact that the two lateral hooks in *N. emydis* are somewhat longer and distinctly heavier than the dorsal and ventral members of the terminal series. These observations constitute the only instance in the Acanthocephala wherein the lateral hooks are distinctively larger than the dorsal and ventral hooks of the same series. A similar distinction has been observed in a few species of the genus *Neoechinorhynchus* from fishes but the degree of difference is usually not as pronounced as observed in *N. emydis* and becomes evident only when the proboscis is mounted so that it can be viewed in full end view since only in such mounts may adjacent hooks be viewed at the same time, without change of focus to disturb the impressions of relative size.

In southern Florida, Bangham (1940, p. 298) discovered an undetermined species of *Neoechinorhynchus* in the flagfish (*Jordanella floridae* Goode and Bean). A study of this material has revealed that the lateral hooks of the terminal series on the proboscis show a degree of differentiation that has been previously unknown for any member of this genus. Not only are the lateral hooks larger and longer than the dorsal and ventral members of the same series, but the right and the left hooks show an extreme expression of asymmetry. One of the laterals (apparently the right) is extremely long and heavy (Fig. 8) while the other is of about the same length but its proximal and distal parts are highly specialized. The proximal region (Fig. 9) forms a broad sleevelike structure through which a fine spinelike blade extends distally. Viewed from either lateral surface the proboscis presents a bizarre asymmetry (Figs. 6, 7) unparalleled in any other species of the entire phylum.

Three of 71 specimens of *Jordanella* carried very light infections with this new species which is here described under the name *Neoechinorhynchus doryphorus*. In a single specimen of *Fundulus majalis* (Walbaum), visceral cysts were encountered. Most of these cysts were occupied by metacercariae of the provisional genus *Neascus*. In the midst of a series of these cysts one chamber, walled by host tissues, contained a single juvenile specimen of *N. doryphorus*.

Only three of the specimens from the flagfish and the juvenile from *Fundulus majalis* (the striped killifish) have the proboscis extruded fully enough to make out complete details of its structure, but in these the pattern is so uniform that the bizarre condition could not be attributed to an abnormality.

Description.—With the characters of the genus *Neoechinorhynchus*. Body of preserved individuals chiefly elongately cylindrical with an increase of diameter near the anterior extremity from which a narrowed truncated cone (about 300μ long; 81 to 92μ wide anteriorly, 115 to 173μ wide posteriorly) makes transition from the widest part of the trunk to the diameter of the narrow neck. Observed individuals 4.38 to 6.4 mm long, enlarged anterior part 289 to 577μ in diameter, the diameter in reduced posterior extremity of the body 289 to 403μ in diameter. Proboscis (Figs. 6, 7) 93 to 132μ wide by 96 to 120μ long. Anterior series of proboscis hooks very prominently distributed as two dorsal, two ventral and two highly modified lateral hooks, one on each lateral surface. Ventral and dorsal hooks of approximately the same size, 61–72μ long with a diameter of 14 to 16μ at their heaviest part. The two lateral hooks of the terminal series (Figs. 8, 9) very conspicuously larger than the dorsals and ventrals and differing markedly from each other in form. Because of twisting of bodies of available individuals it can not be stated definitely if their locations are constantly the same but in two individuals the one on the right side of the proboscis was unmodified (Fig. 8) except for extreme

size (105–132μ long with a diameter of 24 to 26μ), while the one on the left side (Fig. 9) was highly modified consisting of an enlarged, sleevelike basal half about 65μ long by 16μ in diameter from the distal extremity of which a fine thorn of about the same length but only about 5μ in diameter protrudes. Hooks of middle series 29 to 32μ long; those of basal series 26 to 32μ. Lemnisci in females obscured by developing eggs, in one male extending to the level of the anterior testis. Male genital organs occupying more than two-thirds the length of the body cavity. Cement ducts long. Subcuticular giant nuclei conspicuous but not causing elevations on surface of body wall. Hard shelled embryos 48 to 55μ by 14 to 16μ wide, with small rounded polar prolongation of the middle membrane.

Host.—*Jordanella floridae* Goode and Bean of the Englewood area in Florida. Juvenile found once in visceral cyst in *Fundulus majalis* (Walbaum) of the same area.

Type material.—Holotype female, U.S.N.M. Helm. Coll. no. 37136. Allotype male (VC 4189.2) and paratype females in collection of H. J. Van Cleave, Urbana, Ill.; paratype female in collection of R. V. Bangham, Wooster, Ohio.

SUMMARY

A study of new materials of the family Neoechinorhynchidae from fresh-water fishes of Ohio, Florida, Wisconsin, and Canada has revealed four new species, of which one (*Paulisentis fractus*) represents a new genus while the other three are distinctive species of the genus *Neoechinorhynchus* (*N. saginatus*, *N. tumidus*, and *N. doryphorus*, n. spp.). All seem to have distinctive host relationships.

Speciation in the family Neoechinorhynchidae, paralleling evolutionary progress of the hosts in fresh-water fishes of North America, is expressed at two different levels. At the lower of these, distinct species are differentiated. At a higher level, quantitative and qualitative morphological changes make their appearance in structures which taxonomists have come to regard as capable of reflecting generic distinctions. There is no evidence of the degree of diversification expressed by the host being directly paralleled by the degree of diversification of its parasites, since in the same host species a unique genus and a peculiar species have been found existing in the same species of host at the same time.

In the creek chub, *Semotilus atromaculatus atromaculatus* (Mitchill), of Ohio streams, *Paulisentis fractus*, n.gen., n.sp. occurs, while in the same host species from Wisconsin a characteristic species of *Neoechinorhynchus*, *N. saginatus*, n.sp., is recognized.

N. tumidus, n.sp., is described from *Leucichthys artedi* (LeSueur) of Trout Lake, Wis., and from the same host in Waskesin Lake, Saskatchewan. In the latter habitat, *Coregonus clupeaformis* (Mitchill) is likewise its definitive host.

N. doryphorus, n.sp., from the flagfish (*Jordanella floridae* Goode and Bean) is described from Florida in the Englewood area. This species has the most pronounced diversification of the lateral hooks of the terminal series that has ever been observed for any member of the entire phylum. It far exceeds the differentiation found in *N. emydis* since it involves entirely different types of morphological modifications for the median hook on each of the two lateral surfaces of the proboscis.

NOTE ON ILLUSTRATIONS

All figures were drawn from stained whole permanent mounts with the aid of a camera lucida. Katharine Hill Paul, scientific artist in the Department of Zoology of the University of Illinois, executed all the drawings and arranged the plates.

SYMBOLS

B—copulatory bursa
C—cement gland
G—giant subcuticular nucleus
L—lemniscus
O—terminal organ of proboscis
P—proboscis
R—cement reservoir
T—testis
I to V—series of proboscis hooks

LITERATURE CITED

BANGHAM, R. V. *Parasites of fresh-water fishes of southern Florida*. Proc. Florida Acad. Sci. **5**: 289–307. 1940.

———. *Parasites of fish of Algonquin Park Lakes*. Trans. Amer. Fish. Soc. **70**: 161–171. 1941.

———. *Parasites of northern Wisconsin fish*. Trans. Wisconsin Acad. Sci., Arts and Lett. **36**: 291–325. 1947.

BANGHAM, R. V., and HUNTER, G. W. 3D. *Studies on fish parasites of Lake Erie: Distribution studies*. Zoologica **24**: 385–448. 1939.

HUBBS, C. L., and LAGLER, K. F. *Guide to the fishes of the Great Lakes and tributary waters.* Cranbrook Inst. Sci. Bull. **18:** 1–100. 1941.

LINCICOME, D. R. *Observations on* Neoechinorhynchus emydis *(Leidy) an acanthocephalan parasite of turtles.* Journ. Parasitol. **33:** 51–54. 1948.

LÜHE, M. *Geschichte und Ergebnisse der Echinorhynchen-Forschung bis auf Westrumb* (1821). Zool. Annal. **1:** 139–250. 1904.

MEYER, A. *Acanthocephala.* Bronn's Klassen und Ordnungen des Tierreichs **4**(2). 1932–33.

VAN CLEAVE, H. J. *Seasonal distribution of some Acanthocephala from fresh-water hosts.* Journ. Parasitol. **2:** 106–110. 1916.

———. *An analysis of hook measurements in the Acanthocephala.* Vol. Jubilare pro Prof. Sadao Yoshida **2:** 331–337. 1939.

———. *Hook patterns on the acanthocephalan proboscis.* Quart. Rev. Biol. **16:** 157–171. 1941.

———. *A new species of the acanthocephalan genus* Illiosentis *(Rhadinorhynchidae).* Journ. Parasitol. **31:** 57–60. 1945.

———. *The Eoacanthocephala of North America including the description of* Eocollis arcanus, *new genus and new species, superficially resembling the genus* Pomphorhynchus. Journ. Parasit. **33:** 285–296. 1947.

———. *The acanthocephalan genus* Neoechinorhynchus *in catostomid fishes of North America, with descriptions of two new species.* Journ. Parasit. (in press).

——— and LYNCH, J. E. *The circumpolar distribution of* Neoechinorhynchus rutili, *an acanthocephalan parasite of fresh-water fishes.* Trans. Amer. Micr. Soc. (in press).

——— and MANTER, H. W. *A new species of the acanthocephalan genus Filisoma from the Dry Tortugas, Florida.* Journ. Parasitol. **33:** 487–490. 1948.

——— and MUELLER, J. F. *Parasites of Oneida Lake fishes. Part III: A biological and ecological survey of the worm parasites.* Roosevelt Wild Life Ann. **3:** 159–334. 1934.

HERPETOLOGY.—*Notes on a collection of reptiles and amphibians from the Isthmus of Tehuantepec, Oaxaca.*[1]

HOBART M. SMITH AND DAVE A. LANGEBARTEL, University of Illinois. (Communicated by HERBERT FRIEDMANN.)

During late 1948 and early 1949, Thomas MacDougall, aided by a number of local residents of Tehuantepec, secured a series of 40 unusually noteworthy specimens of reptiles and amphibians in the vicinity of the Isthmus of Tehuantepec. These are now in the Museum of Natural History of the University of Illinois, to which all specimen numbers cited in the following discussion refer. We are much indebted to Mr. MacDougall for his kindness in accumulating this material under difficult circumstances and for providing detailed information regarding habitats and localities.

Especially noteworthy in this collection of 21 species are a new species of *Ficimia* and another of *Rhadinaea*, two new State records (*Leiolopisma cherriei stuarti* and *Coniophanes fissidens fissidens*), and two aberrant specimens of *Pliocercus e. elapoides* and *Micrurus ephippifer*. All these except the last were obtained in the little-explored area north of Niltepec. If, as was the case, six specimens from this region proved to be of such novel interest, the area must be one that would well repay more intensive exploration. It is unfortunate that the area is so difficult of access.

Localities from which the specimens were taken, all within the state of Oaxaca, are not all readily found on maps generally available. The following list is given of those not on the American Geographical Society's 1938 map of the area, scale 1:1,000,000 (distances straight-line, unless otherwise stated):

CERRO CALDERONA: 3 miles north-northeast of Matías, about 13 (15 by trail) miles west-northwest of Tehuantepec; north of Cerro San Pedro.

RANCHERÍA SANTA LUCÍA: About 15 (20 by trail) miles west-southwest by west of Tehuantepec.

ESCURANO: Lower slopes of Cerro San Pedro, about 15 miles west-northwest of Tehuantepec.

LA GLORIA: 30 miles north of Niltepec; about 50 miles northeast of Tehuantepec.

NISABIBI: 2 miles west of Yerba Santa near foot of Cerro San Pedro.

PORTILLO GUAYABO: 16 miles due west of Tehuantepec.

RÍO GRANDE: 15 miles north of Niltepec, and 1–2 miles downstream from Scarces; 50 miles northeast of Tehuantepec.

SAN PABLO TOPILTEPEC: 55 miles west-southwest of Tehuantepec (about 85 miles by trail).

SANTO TOMÁS TEIPAN: 49 miles (about 65–70 miles by trail) west-southwest of Tehuantepec (listed as Teipam on map).

[1] Contribution from the Museum of Natural History and Department of Zoology, University of Illinois, Urbana. Received July 26, 1949.

Thorius minutissimus Taylor

"Six topotypic specimens (nos. 3754–59) are from the small, isolated area of cloud forest at Santo Tomás Teipan (cited incorrectly as 'Tecpan (S. Tomás)' on some maps). Two possess two premaxillary teeth penetrating the lip. The largest specimen measures 22 mm from snout to vent. The nostril is relatively small, and the subnarial swelling reduced in all. The chief feature distinguishing this species from *narisovalis* apparently is the markedly greater extent of fusion of the digits. The eyelids are darkened. The number of caudal grooves apparently is not significant; our three specimens with complete tails have 31, 34, and 35 caudal grooves." (Quotation from Taylor, in letter.)

Mabuya mabouya mabouya (Lacépède)

Two adult specimens (nos. 3760–61) are from Nisabibi, both collected on March 25, 1949. The specimens are typical with a dark lateral stripe bordered below by a sharply defined light line, above by a poorly defined light line; one pair of nuchals; 4 supraoculars; fifth supralabial subocular in position; supranasals separated; prefrontals separated; parietals in contact; scales around middle of body 28, 30; scales from chin to vent, 59, 60; toes overlapping when adpressed. The specimens measure 67 and 73 mm, respectively, from snout to vent.

Leiolopisma cherriei stuarti (Smith)

A single adult (no. 3762) is from the Pacific slopes of the main ridge of the Sierra Madre between Río Grande and La Gloria, elevation about 3,000 feet, in pine stands. The interparietal is single, the scale rows at midbody 30, the dorsals from parietal to base of tail 69, the tail of a slightly bluish cast. The specimen measures 50 mm from snout to vent, the tail 93 mm.

The dorsal scale count, in which lies the chief difference between *L. c. cherriei* and *L. c. stuarti*, is 69 in this specimen and thus clearly refers the specimen to *L. c. stuarti*, in which the dorsal counts average 69.1 (range 65 to 72). In *L. c. cherriei* the counts average 63.2 and vary from 59 to 67.

This race has not previously been recorded in the state of Oaxaca. The present specimen extends the known range from the foothills of central Veracruz across the Isthmus of Tehuantepec to extreme eastern Oaxaca—a distance of about 300 miles. Although the species was to be expected to occur in the state of Oaxaca, presumably inhabiting all the foothills from Córdoba, Veracruz, to Palenque, Chiapas (between which localities no specimens have previously been recorded), the subspecific ranges were entirely a matter of conjecture. As a matter of fact the race to be expected in the area represented by the present specimen was *L. c. cherriei*, because of apparently closer zoogeographic affinity of this area and the known limits of the range of the race.

Gymnophthalmus sumichrasti (Cope)

A single, somewhat mutilated adult (no. 3763) is from Escurano. The mental is in contact with two large postmentals, which are broadly in contact medially and followed by a similar pair; 4 supralabials to rear margin of eyes; dorsals 33; scale rows at midbody 13; femoral pores 5–5; 38 mm from snout to vent; tail 61 mm; tail a light tan, body dark brown above.

Heloderma horridum Wiegmann

A single half-grown specimen (no. 3764) is from La Concepción, taken on March 19, 1949. It measures 215 mm from snout to vent, the tail 196 mm. The pattern is typical, predominantly of black but with prominent yellow areas.

Dryadophis melanolomus tehuanae Smith

A single subadult male (no. 3765) is from Cerro Calderona, collected on August 29, 1948. Scale rows 17–17–15; ventrals 181; caudals 109; supralabials 9–9; infralabials 10–10; preoculars 1–1; postoculars 2–2; temporals 1–2 on one side (normal), 2–2 on the other (abnormal, with two tiny upper anterior temporals in succession, bordering above the large lower anterior temporal); total length 805 mm, tail 240 mm.

Drymarchon corais melanurus (Duméril, Bibron, and Duméril)

One specimen (no. 3766), from La Gloria, March 9, 1949, is referred to this subspecies in spite of the fact that it belongs to the wide-ranging "intergrade" populations between *D. c. melanurus* and *D. c. rubidus*. The specimen, a juvenile male, measures 700 mm in total length, the tail 134 mm; scale rows 19–17–15; ventrals 192; caudals 82; supra- and infralabials 8–8; preoculars 1–1; postoculars 2–2; temporals 2 + 2, 2 + 2; antepenultimate labial in contact with temporal.

In spite of the derivation of this specimen from Atlantic slopes where typical *D. c. melanurus* might be expected, the snake appears to agree

perfectly with the so-called intergrades between *D. c. melanurus* and *D. c. rubidus* described by Smith (Journ. Washington Acad. Sci. **31**: 476. 1941). The dorsal surface, except on the tail, is relatively light (as in *melanurus*); the first preocular labial (i.e., the third supralabial) possesses a dark posterior border (intermediate); the lateral gulars have slightly darkened tips (as in *rubidus*); many ventrals have a distinct dark posterolateral mark on each side (as in *rubidus*); the light transverse dorsal bands appear to be but one scale wide (as in *rubidus*); the head is light, and the labials appear to be pale brown (as in *melanurus*).

Ficimia ramírezi,[2] n.sp.
(Fig. 1, *right*)

Type.—No. 3767, an adult male, collected by Juan Ramírez 1 league north of Niltepec, Oaxaca, March 6, 1949.

Diagnosis.—A member of the genus *Ficimia*, with 20 poorly defined chocolate-brown blotches on back, separated from one another by spaces two to three times their own length, very incompletely bordered with black; no dark markings on head; two internasals; two postoculars; ventrals 136, caudals 38 in single known male.

[2] Named for Sr. Juan Ramírez, a resident of Tehuantepec, who collected the type and assisted the senior author when visiting the Tehuantepec area nearly 10 years ago and who has for 15 years or more faithfully aided Thomas MacDougall in carrying out intensive field work in the Tehuantepec area.

Description of type.—Rostral large, in contact with frontal, suture with latter one-half maximum width of rostral; internasals well developed, about size of preocular; anterior half of nasal fused with 1st supralabial; prefrontal broadly in contact with second supralabial; 1–1 preoculars; 2–2 postoculars; eye relatively large, its vertical diameter equal to its distance from labial border, its longitudinal diameter one-fourth longer; temporals 1–2, the anterior elongate, the secondaries similar in shape to dorsals; frontal as long as broad, equally as long as its distance from tip of snout; supralabials 7–7; infralabials 7–7, the anterior 3 in contact with chinshields; 1 pair of chinshields.

Dorsals in 17–17–17 rows, smooth even in supraanal area, each with a single apical pit; ventrals 136, caudals 38; total length 325 mm, tail 54.

Hemipenis 10 caudals long, simple and with simple sulcus; 2 large basal spines; spines occupying basal third, becoming smaller distally and merging with calyces; several longitudinal plicae extending through both spinous and calyculate zones.

Dorsal color a light slate; head tan above; 20 light chocolate brown blotches on body, each 1½ to 2 scales in length, 5 to 8 scale rows wide, separated from one another by spaces two to three times as long as the blotches; a very incomplete black border on the blotches; some blotches,

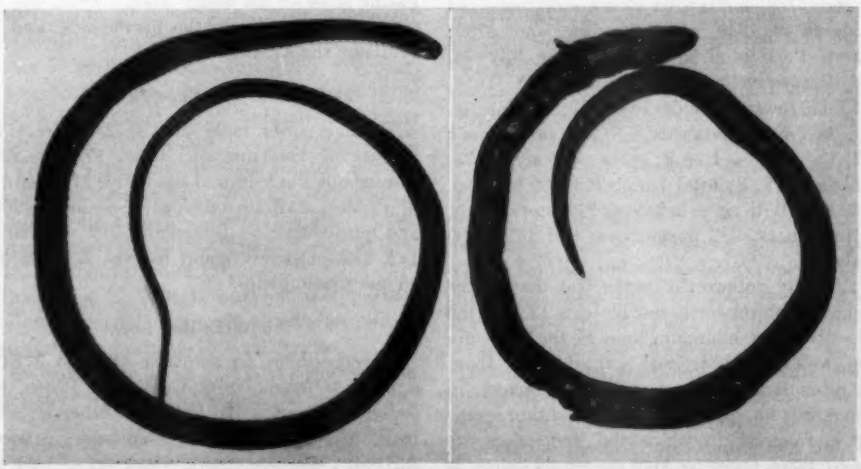


FIG. 1.—*Left: Rhadinaea macdougalli*, n. sp., holotype. *Right: Ficimia ramírezi*, n. sp., holotype.

especially toward rear of body, preceded and succeeded by a small, poorly defined light spot on the midline; a few scattered, dark lateral streaks; median dorsal blotches showing a tendency to have the lateral edges split off (as typical of most species of this genus); 8 dorsal blotches on tail; ventral surfaces immaculate; no markings on head.

Remarks.—The present species differs remarkably in pattern from all other species of the genus. While *publia* is known to have as few as 21 blotches, they are approximately as broad as the interspaces, while in *ramirezi* the anterior blotches are separated by interspaces twice their own length, the interval gradually increasing posteriorly to three times as the blotches decrease in size. This feature of the pattern is not approached by other members of the genus. Other features distinguishing this specimen from *publia* is the absence of lateral blotches and of any pattern on the head.

The derivation of this specimen from an area where *publia* is to be expected casts some doubt upon its validity. Only further specimens can prove beyond reasonable doubt the validity of the supposed species. Certainly a sufficient number of unique features in pattern occur in the type of *ramirezi* to warrant the provisional assumption of the existence of a distinct species.

Ficimia publia publia Cope

Two specimens, the twenty-first and twenty-second known of this subspecies, are available; one (no. 3768) is from La Concepción, collected on March 19, 1949, while the other (no. 3769) is from Portillo Grande, collected on July 26, 1948. Respectively the dorsals are in 18–17–17, 17–17–17 rows; ventrals 154, 137; caudals 35 (♀), 38 (♂); infralabials 8–8, 7–8; temporals 1 + 2, 1 + 2/1 + 1 + 2; spots on body 27, 23; spots on tail 8, 8; total length 262, 199 mm; tail 38, 32 mm. Both agree in having 7–7 supralabials, 1–1 preoculars, 2–2 postoculars, and 1–1 internasals.

Especially noteworthy is the fact that in the specimen with relatively few blotches (23) on the body (21 is the minimum known) the spots are large, well defined, at least a third longer than, and often twice as long as the interspaces; in other words no approach to the condition occurring in *ramirezi*, in which the interspaces are two to three times as long as the blotches, is indicated.

Manolepis putnami (Jan)

A single young female (no. 3770) is from San Pablo Topiltepec, collected early in 1949. It has 19–19–15 scale rows, 181 ventrals, 75 subcaudals, 8–8 supralabials, 10–10 infralabials, 1–1 preoculars, 2–2 postoculars, 1–2–2 temporals, no loreal, total length 256 mm, tail 53 mm.

Pliocercus elapoides elapoides Cope

A single juvenile female (no. 3771), was collected in rain forest between Río Grande and La Gloria (4,000–4,500 feet elevation), March 7, 1949. It has 17–17–17 scale rows, 130 ventrals, 93 caudals, 8–8 supralabials, 9–9 infralabials, 2–2 preoculars, 2–2 postoculars, 7 primary black rings on body (all complete), 5 on tail; total length 200 mm, tail 71 mm. The black borders of the yellow rings are much wider than the yellow rings both on body and tail.

Two unusual features, both in pattern, are noteworthy: (1) a black middorsal band extends the length of each red zone, connecting the two black borders of that zone with each other; and (2) the parietal yellow ring is completely interrupted on the top of the head for a width about equal to that of a frontal. The reduced number of primary rings is likewise very unusual for *e. elapoides*. Despite the magnitude of these discrepancies it is impossible to determine their significance in the absence of further specimens from the Pacific coast and Isthmus areas. The specimen was taken in rain forest very near the crest on the Pacific slope of the Sierra Madre which lies between Río Grande, on the Pacific side, and La Gloria on the Atlantic.

Enulius unicolor (Fischer)

A single adult male (no. 3772) is from the vicinity of Tehuantepec. It has 17 scale rows throughout the length of the body; 174 ventrals, 67 caudals (tail tip missing); 7–7 supralabials; and infralabials; no preoculars; 2–2 postoculars 1–2, 1–2 temporals; snout to vent 220 mm, tail 85 mm (incomplete).

Tantilla rubra Cope

Two specimens are available. One (no. 3773) is a juvenile female from Cerro San Pedro, collected on January 20, 1949, the other an adult male (no. 3774) from Tehuantepec, collected early in 1949. Respectively they have 155, 147 ventrals; caudals 59, 51+; total length 195 mm,

330+ mm; tail 43 mm, 67+ mm. Both agree in having 7–7 supralabials and infralabials, 1–1 preoculars, 2–2 postoculars, and 1–1 temporals. The two anterior infralabials are in contact medially in each, and the yellow nuchal ring barely involves the tip of the parietals in one, clearly does so in the other. Coloration typical.

Rhadinaea macdougalli,[3] **n.sp.**

Fig. 1, *left*

Type.—No. 3775, male, collected by Thomas MacDougall on March 7, 1949, near Buena Vista, at crest of Sierra Madre, 4,000–4,500 feet, directly north of Río Grande, Oaxaca.

Diagnosis.—A member of the genus *Rhadinaea*, with 17 scale rows, ventrals about 119, caudals about 75, in males; no supraanal keels; maxillary teeth 16 + 2, with a short but well-defined diastema preceding the two rear teeth; hemipenis capitate, sulcus divided, with about 22 large spines in a belt around the middle, and numerous fine spines to base. Sides below upper part of fourth scale row darker than back, faintly bordered above by a light line; no other stripe on body; head with a light line through the supralabials and another from upper rear margin of orbit to upper edge of last supralabial; belly immaculate except ends of ventrals, which are darker than adjacent dorsal scales.

Description.—Portion of rostral visible from above two-thirds length of median internasal suture; latter entering 2⅓ times into median prefrontal suture; frontal a little longer than its distance from tip of snout; nasal large, completely divided; loreal square; 3 preoculars and 2 postoculars on each side; temporals 1–2–3; eye large, its longitudinal diameter entering 1⅓ times in its distance from tip of snout, one-half time in its distance from labial border; 8 supralabials, fourth and fifth entering orbit, seventh largest; 10 infralabials, 5 in contact with anterior chinshields, 2 with posterior; anterior chinshields a little shorter than posterior, the members of each pair in contact throughout their length.

Dorsals in 17 rows throughout body; scales absolutely smooth even in supraanal area, pitless; ventrals 119, subcaudals 75; anal divided.

Maxillary teeth 16 + 2, steadily increasing in size posteriorly to the sixteenth, the anterior one about two-thirds length of sixteenth; rear two teeth abruptly enlarged one-fourth more than preceding tooth.

Hemipenis single, 8 caudals long, capitate, calyculate, sulcus dividing opposite 6th caudal; a belt of 22 large spines of various sizes around middle third of hemipenis, below calyces; numerous minute spines on basal third of hemipenis, which appears to be provided with longitudinal ridges; some minute spines also scattered among large spines.

Total length 294 mm; tail 106 mm.

Dorsal color a nearly uniform dull, dark brown; edges of each scale darker than middle; sides a little darker than middorsum, the darker color abruptly terminating at a moderately distinct black line on upper part of fourth scale row; centers of scales in fifth scale row not as dark but lightly stippled, giving the effect of a faint light line; rest of dorsum uniform. Head light brown above, little stippled with darker; a sharply defined white line extending from upper rear corner of eye through temporals to upper edge of last supralabial, there abruptly terminating, partly on the labial and partly on the scale immediately above; another white line through rostral and across upper edges of the fifth and preceding supralabials, through the middle of the sixth, barely involving the anteroventral corner of the eighth, where it ends at the lip; both white stripes bordered by broad black lines, continuous except for that below the supralabial line which is interrupted at each labial suture, producing the effect of a row of spots on the lower edges of the labials, one spot to each scale. Dorsolateral light line of body rather distinct as it nears head, curving laterally toward temporal stripe, but terminating abruptly in a rounded, black-edged, small expansion which fails to reach the end of the temporal stripe by two scale lengths; a dark spot on each of the anterior four infralabials, two on the mental, and one on each anterior chinshield at its anterior end; a few flecks in lateral gular region. Ventrals and subcaudals entirely immaculate, white, except the extreme lateral ends which anteriorly are black tipped, elsewhere brown as the sides of the body and tail.

Remarks.—The relationships of this distinct species are difficult to determine. Of the Mexican species now known only the recently described *R. marcellae* Taylor (Univ. Kansas Sci. Bull. **33**: pt. 1 (2): 197, 1949) appears to be related. None

[3] Named for Thomas MacDougall, collector, who for 10 years has assisted the senior author to become acquainted with the Tehuantepec area.

of the Central and South American species appear the same. Taylor's species, based upon a male (Taylor, correspondence) possesses only 2 preoculars, a nuchal collar, a dorsal scroll-like pattern on the head, only 4 infralabials touching anterior chinshields, 8–9 infralabials, a quadrangular loreal, etc. (in *macdougalli*, 3 preoculars, no nuchal collar, no scroll-like pattern on head, 5 infralabials touching anterior chinshields, 10 infralabials, a square loreal). These differences are relatively minor, and point toward a close relationship between *marcellae* and *macdougalli*. In a way the two species seem somewhat intermediate between the isolated *decorata* and the *taeniata—quinquelineata* groups, having the low ventrals and certain features of the dorsal pattern of the former, but the low caudals and certain features of the head pattern of the latter. The species are not related, apparently, to the enigmatical *Erythrolamprus mentalis* Werner, which

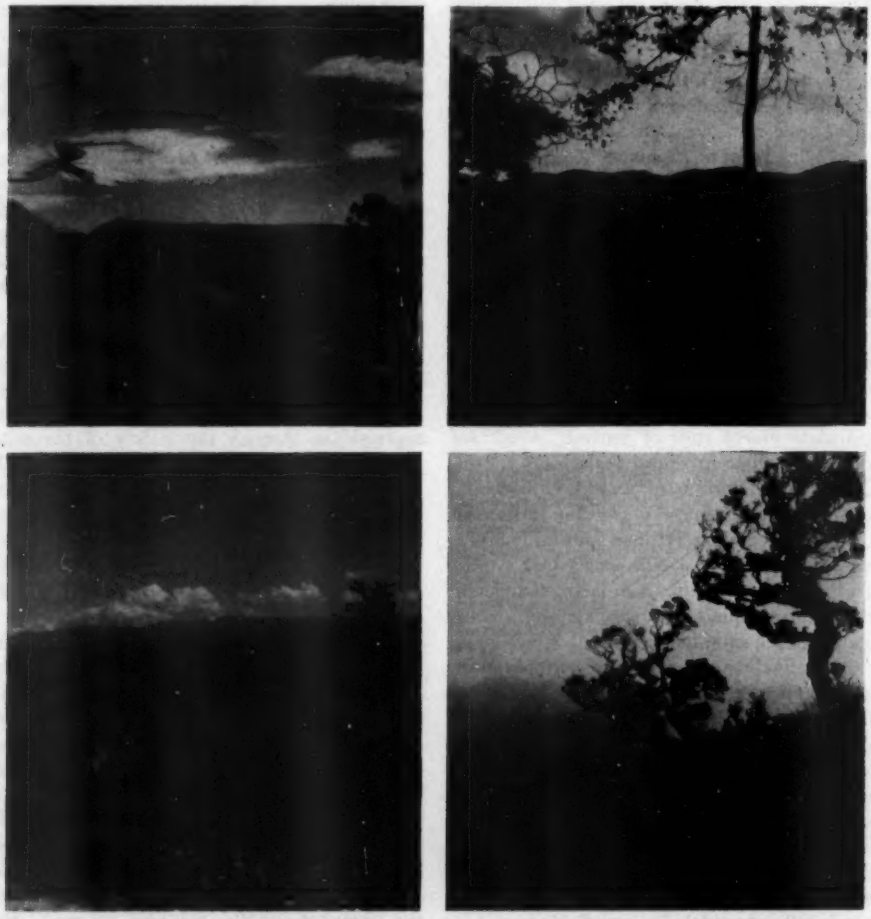


FIG. 2.—*Upper left:* Dry Pacific (southern) slopes of the Sierra Madre north of Niltepec, Oaxaca, on the trail from Río Grande to La Gloria, looking eastward toward Cerro Atravesado, which extends in a north-south direction. *Upper right:* View toward east, paralleling the Sierra Madre, from La Gloria. *Lower left:* View toward south from Santa María Chimalapa, on the Río Coatzacoalcos and not far from La Gloria; the Sierra Madre is in the distance, the highest peak (just to the right of which the Río Grande–La Gloria trail crosses) slightly to right of center. *Lower right:* Northern slope of the Sierra Madre north of Niltepec on the trail from Río Grande to La Gloria. Photos courtesy of Thomas MacDougall.

TABLE 1.—VARIATION IN LEPTODEIRA MACULATA

No.	Sex	Scale rows	Ventrals	Caudals	Supralabials	Infralabials	Preoculars	Postoculars	Dorsal and caudal blotches	Total length	Tail length
										Mm	*Mm*
3781	♂	21–23–17	174	72	8–8	9–9	1–2	2–2	26+12	525	109
3782	♂	19–23–17	174	—	8–8	10–10	2–2	2–2	27+—	450+	47+
3780	♂	21–23–17	176	71	8–8	10–10	2–2	2–2	29+—	535	113
3779	♂	21–23–17	170	71	9–9	10–10	2–2	2–2	29+13	508	109
3786	♂	21–22–17	173	—	8–8	10–10	—	—	28+—	419	74
3784	♂	21–23–17	176	71	8–8	10–10	2–2	2–2	29+—	535	113
3783	♀	23–25–17	177	66	8–8	10–10	2–2	2–2	31+13	395	80
3785	♀	23–25–17	172	67	—	—	2–2	2–3	29+12	362	74

has 147 ventrals, 1 preocular and a very different color pattern.

Coniophanes imperialis copei Hartweg and Oliver

A single specimen (no. 3776) is from La Finca (Tehuantepec), collected on April 2, 1949. It is a typical subadult female measuring 231 mm snout to vent (tail broken); scale rows 19–19–17; ventrals 130; supralabials 8–8; infralabials 9–9; preoculars 1–1; postoculars 2–2; temporals 1–2, 1–2. The dorsal stripe is very narrow and continuous, and the lateral dark stripe is distinctly darker on its upper half.

Coniophanes fissidens fissidens (Günther)

One specimen (no. 3777) is from La Gloria. It is a subadult male with anal ridges; scale rows 21–21–17; ventrals 126; caudals 78; supralabials 8–8; infralabials 10–10; preoculars 1–1; postoculars 2–2; temporals 1–2, 1–2; 435 mm total length; 137 mm tail length. Generally one, occasionally 2 distinct dark spots, about 0.5 mm in diameter, at end of each ventral and on each subcaudal; no dark dorsal spots such as occur in *C. f. punctigularis;* median dark border of dorsolateral light stripes confined to tail, not present on rear part of body; whitish portion of dorsolateral light stripes back of head relatively short, little more than twice length of head.

This subspecies has never before been recorded from the state of Oaxaca, although its occurrence in this poorly known, humid Atlantic exposure was to be expected. The specimen definitely does not agree with others (Mus. Comp. Zool. nos. 27702–18, *C. f. dispersus*) from Tapanatepec on the Pacific slopes of the Isthmus only 40 miles distant. The two localities, however, are in very markedly different zoogeographic areas.

Imantodes splendidus oliveri Smith

One female (no. 3778) is from Nisabibi, collected on March 25, 1949, and another female (no. 4001) is from Tehuantepec. Respectively they have 17–17–16, 17–17–17 scale rows; 220, 230 ventrals; 121, 129 caudals; 9–9, 8–8 supralabials; 10–10, 10–? infralabials; 1–1 preoculars, 2–2 postoculars, 1–2 temporals; supralabials 4–5–6, 3–4–5 entering orbit; 57, 59 bands on body; all bands broken laterally except on anterior third, two-fifths of body; total length 431, 440 mm; tail 113, 120 mm.

Leptodeira maculata (Hallowell)

Eight specimens are in the collection. Two (nos. 3779–80) are from Nisabibi, four (nos. 3781–4) from Tehuantepec, one (no. 3785) from Cerro Santa Lucía, and one (no. 3786) from Cerro Calderona. Variation in certain characters is given in Table 1.

Leptodeira mystacina Cope

Two adult females are available: No. 3787, from Escurano, collected on July 30, 1948, and no. 3788, from La Concepción, collected on March 18, 1949. Respectively the ventrals are 192, 186; subcaudals 64–61; supralabials 7–8, 8–8; infralabials 9–10, 10–10; dorsal bands 11, 13 on body, 5, 5 on tail. Both agree in having 19–19–17 scale rows, 1–1 preoculars, 2–2 postoculars, 1 + 2 temporals.

Stenorrhina freminvillii freminvillii Duméril, Bibron, and Duméril

Two specimens are in the collection: No. 3789 from Escurano, March 9, 1949, and no. 3790 from Cerro San Pedro, January 13, 1949. Respectively, ventrals are 171, 166; subcaudals 32, 44; tem-

porals 2 + 2 (anomalous), 1 + 2; total length 430, 170 mm; tail length 54, 25 mm. Both agree in having 7–7 supralabials and infralabials, 1–1 loreals, 1–1 preocular, 2–2 postoculars, 17 scale rows throughout length of body, anterior half of nasal fused with internasal. Despite the great difference in size between the specimens, the coloration is virtually identical and is indicated as essentially constant throughout life. The body is salmon-pink above, a little lighter below; a very faint middorsal dark streak in the adult, well defined and one-half a scale row wide in the juvenile; a dark line through eye, faintly continued along sides between the third and fourth scale rows.

Micrurus ephippifer Cope

Two specimens are in the collection. One is a typical female (no. 3791) from La Concepción, collected March 20, 1949. It measures 470 mm in total length, the tail 53 mm (ratio, tail to total length, 0.113); scale rows 15–15–15; ventrals 221; caudals 42; supralabials 7–7; infralabials 6–6; preoculars 1–1; postoculars 2–2; temporals 1–1, 1–1; primary black rings on body 22, on tail 5 (not counting black tip); red zones replaced by black on most of dorsal scale rows, ventrally to the first scale row or edge of ventrals; ventrals rather extensively marked with black in red zones, so that from one-half to one-sixth the area is occupied by black in any one zone; red zones 2–7 ventrals long, usually 4; yellow rings 1 or 2 ventrals long, usually 1; black rings 4–5 ventrals long, usually 4; black nuchal ring extending 6 scale lengths back of parietals, the posterior tips of which are involved; yellow parietal ring not reaching anterior edge of parietals, barely touching posterior tip of frontal; red rings usually forming a very narrow fringe in front of and behind the black dorsal blotch.

The other specimen (no. 3792) is an adult male from Nisabibi, collected on March 28, 1949. It is most extraordinary in the great reduction in number of all rings, and the restriction of the dorsal black blotches of the red rings to the area between the third, fourth, or fifth scale row of each side. The scale rows are 15–15–15 and without any evidence whatever of supra-anal tubercles or keels; ventrals 218; caudals 56; supralabials 7–7; infralabials 6–6; preoculars 1–1; postoculars 2–2; temporals 1–1, 1–1; black rings on body 13, on tail 4 (not counting black tip); total length 695 mm, tail length 105 mm (ratio tail to total length, 0.151). Yellow rings relatively wide, as frequently 2 ventrals long as 1; black rings 5–7 ventrals long, usually about 6; red rings 8–10 ventrals long, usually 9; black dorsal saddles in red rings 7 scales in length on anterior half of body, 6 on posterior half, completely interrupting red rings anteriorly but failing to do so on posterior half of body; half of black saddles extending laterally onto fourth scale row, half only onto fifth; nuchal black ring covering 9 scale lengths, barely touching posterior tips of parietals; each red ring with a few small scattered black flecks both above and below.

The aberrant specimen possesses fewer black rings (13) on the body than any other specimen reported. The nearest approach is a record (Woodbury and Woodbury, Journ. Washington Acad. Sci., **34:** 371. 1944) of a specimen with 16 black rings. The low number is not sexually significant, as a male from Llano Ocotal (EHT no. 27533) possesses 21 black rings. Other specimens have been reported with from 18 to 23 black rings. While the indicated range of variation, 13 to 23, is extraordinarily large, it is matched by another species, *M. nigrocinctus browni*, in which the range is 11 to 24.

In view of (1) the absence of differences other than pattern from more typical *M. ephippifer;* (2) the existence of at least one intermediate of 16 between the extremes of 13 and 18–23 of the counts for black rings; (3) the derivation of the questioned specimen from the same area from which more typical *M. ephippifer* has been obtained; and (4) the occurrence of an even greater range of variation in black-ring count in at least one other species of the genus than would be obtained by placing this specimen with *M. ephippifer*, we regard it highly improbable that the present specimen represents a species other than *M. ephippifer*.

MAMMALOGY.—*Two new wood rats from eastern Utah.*[1]

KEITH R. KELSON, University of Utah. (Communicated by HERBERT FRIEDMANN.)

A study of variation in rodents from the Colorado River drainage of Utah revealed that certain populations of wood rats of the species *Neotoma cinerea* and *Neotoma lepida* were sufficiently differentiated from known subspecies to warrant separation and naming. I am indebted to Stanley P. Young and the U. S. National Museum for the loan of comparative material and to the University of Utah Research Council for financial assistance in obtaining the specimens reported upon here. Unless otherwise indicated, all specimens are in the collection of the Museum of Zoology, University of Utah. Measurements are given in millimeters.

Neotoma cinerea macrodon, n. subsp.

BIG-TOOTHED WOOD RAT

Type.—Male, adult, skin and skull, no. 4725, Museum of Zoology, University of Utah, east side of the confluence of Green and White Rivers, 1 mile southeast of Ouray, 4,700 feet, Uintah County, Utah; August 21, 1946; collected by Keith R. Kelson, original number 120.

Range.—Known only from the northern edge of the East Tavaputs Plateau, Uintah County, Utah.

Diagnosis.—Size small (see measurements); hind foot small; tail short (ratio of tail length to head-body length averaging 74.7 percent in a series of 4 adult ♂♂). Color (capitalized color terms after Ridgway, *Color standards and color nomenclature*, Washington, 1912): Upperparts Pale Ochraceous-Buff grading to Light Ochraceous-Salmon on cheeks, shoulders and flanks, thinly overlaid with blackish hairs, underparts white; feet white above; tail distinctly bicolored, dusky above and white below except for a buffy basal band, distal two-thirds narrowly edged with buffy-tipped hairs. Skull: Small, moderately angular; frontonasal region slightly arched, moderately channeled above; temporal ridges well developed and widely separated; interparietal broad between temporal ridges, but relatively short; sphenopalatine vacuities large; auditory bullae moderate in size; alveolar length of upper molar series long and individual teeth large; upper incisors weak.

Measurements.—Average and extreme measurements of 4 ♂♂ and measurements of 2 ♀♀, nos. 6660 and 5893 (the latter showing little tooth wear) are, respectively, as follows: Total length, 348.5 (372–333), 330, 292; length of tail vertebrae, 146 (158–139), 140, 120; length of hind foot, 38.3 (40–36), 39, 37; basilar length, 39.2 (42.1–37.6), 37.4, 35.8; length of nasals, 18.3 (20.6–17.1), 16.9, 16.4; length of incisive foramina, 10.5 (11.6–9.7), 9.9, 10.1; length of palatal bridge, 9.0 (9.4–8.5), 8.4, 7.7; zygomatic breadth, 24.1 (26.2–22.5), 23.2, 21.0; alveolar length of upper molar series, 9.8 (10.1–9.6), 9.7, 9.4.

Comparisons.—From *Neotoma cinerea acraia*, *N. c. macrodon* differs as follows: Tail shorter, hind foot shorter. Color: Generally much lighter, but certain specimens of *N. c. acraia* from the High Plateaus of central Utah are indistinguishable from *N. c. macrodon* in this respect. Skull: Less angular and smaller; frontonasal region less deeply channeled above; cranial roots of the zygomata weaker; sphenopalatine vacuities large as opposed to absent; interparietal usually shorter; auditory bullae less inflated ventrally; upper molar tooth row 7 percent longer; upper incisors less robust.

From *N. cinerea orolestes*, *N. c. macrodon* differs as follows: Size slightly smaller. Color: Markedly lighter. Skull: Frontonasal region less deeply channeled above; sphenopalatine vacuities slightly larger; upper molar tooth row 8 percent longer; zygomatic arches heavier; frontonasal region more arched.

From *N. cinerea arizonae* which it most closely resembles, *N. c. macrodon* differs as follows: Color: Markedly lighter, being buffy rather than tawny, tail duskier above and bushier. Skull: Similar, except the length of the upper molar series is 16 percent longer in comparable male specimens sphenopalatine vacuities larger.

Remarks.—The presence of large sphenopalatine vacuities indicates that *N. c. macrodon* belongs to the same group of wood rats as *N. c. orolestes*, *N. c. arizonae*, and *N. c. rupicola*. Specimens are still too few to ascertain the phylogenetic relationships of the new subspecies with other subspecies of the same complex. The pallid color of *N. c. macrodon* is noteworthy since several

[1] Contribution from the Department of Vertebrate Zoology, University of Utah, Salt Lake City, Utah. Received July 25, 1949.

kinds of mammals from the same general region are also noticeably paler than related subspecies elsewhere. This is most apparent in *Perognathus apache caryi* and *Lagurus curtatus levidensis*.

The designation of the bushy-tailed wood rats from the East Tavaputs Plateau (and, presumably, the southern part of the Uinta Basin) as subspecifically distinct leaves a single specimen in the collections of the University of Utah, no. 967, from Castle Valley, 18 miles northeast of Moab, 6,000 feet, Grand County, as the northernmost known record of *N. c. arizonae* in Utah. This specimen closely resembles topotypical and near topotypical specimens of that subspecies. Two specimens from Vernal, Uintah County (U. S. National Museum), and a single skull, no. 7098, sex unknown, from Myton, Duchesne County, show no intergradation with *N. c. macrodon*. These specimens are best referred to *N. c. orolestes*. Both of these localities are on the opposite side of the Green River.

Specimens examined.—Seven, all from Uintah County, Utah: East side of confluence of Green and White Rivers, 1 mile southeast of Ouray, 4,700 feet, 4; Willow Creek, 25 miles south of Ouray, 5,250 feet, 2; Willow Creek 29 miles south of Ouray, 5,400 feet, 1.

Neotoma lepida sanrafaeli, n. subsp.

San Rafael Wood Rat

Type.—Male, adult, skin and skull, no. 6428, Museum of Zoology, University of Utah, Rock Canyon Corral, 5 miles southeast of Valley City, 4,500 feet, Grand County, Utah; June 20, 1948; collected by Keith R. Kelson, original number 522.

Range.—Eastern Utah between the Colorado River and the High Plateaus, north to the Book Cliffs, south to northern Garfield County.

Diagnosis.—Size small (see measurements); hind foot and tail average for the species. Color: Ground color of upperparts Light Buff to Light Ochraceous-Buff with wash of blackish; cheeks, flanks and shoulders Light Ochraceous-Buff; upperparts of feet white; underparts white, with hairs plumbeous basally except on pectoral, and inguinal regions and on a narrow strip of the belly; tail distinctly bicolored, white below except for a buffy basal band, and dusky above, black hairs being mixed with buffy, the former predominating distally. Skull: Comparatively large, ridged, and angular; frontonasal region slightly arched; moderately furrowed above with well developed supraorbital ridges; temporal ridges well developed; sphenopalatine vacuities moderate; palatal bridge long; upper molar series long and wide.

Measurements.—Measurements of the type, and average and extreme measurements of 5 adult ♂♂, and 1 adult ♀, no. 6429, from the type locality are, respectively, as follows: Total length, 312, 288 (312–267), 300; length of tail vertebrae, 128, 119 (128–115), 129; length of hind foot, 34, 31 (34–28). 31; (cranial measurements are based on 4 adult males) basilar length, 34.2, 33.9 (35.1–32.7), 32.8; length of nasals, 15.1, 14.7 (15.1–14.5), 14.7; length of incisive foramina, 8.5, 8.5 (9.1–8.2), 8.3; length of palatal bridge, 7.7, 7.45 (7.7–7.1), 7.7; interorbital breadth, 5.1, 5.3 (5.4–5.1), 5.3; extension of premaxillary tongues posterior to nasals, 3.2 2.8 (3.2–2.4), 2.5; zygomatic breadth, 21.7, 20.9 (21.7–20.3), 20.7; width of brain case, 16.2, 16.0 (16.2–15.7), 16.3; alveolar length of upper molar series, 8.3, 8.2 (8.5–8.0), 8.3; width of upper molar series, 2.3, 2.3 (2.3–2.25), 2.4.

Comparisons.—From *Neotoma lepida lepida*, *N. l. sanrafaeli* differs as follows: Size slightly larger. Color: Many specimens inseparable as to color, but in general, *N. l. sanrafaeli* averages more buffy. Skull: Larger in every measurement taken; more ridged and channeled above; brain case more rounded and inflated.

From *N. lepida monstrabilis* the nearest subspecies, geographically and morphologically, *N. l. sanrafaeli* differs as follows: Color: Averages much lighter (lighter ground color), but certain specimens of the light phase of *N. l. monstrabilis* are similar to some specimens of *N. l. sanrafaeli*. Skull: Larger in all measurements taken except breadth of brain case in which they are equal; skull more ridged and channeled in the frontonasal region; palatal bridge markedly longer (all adult ♂♂ specimens of *N. l. sanrafaeli* measure more than 7.1, while none of 8 ♂♂ from northern Arizona and 20 ♂♂ from Utah exceeded 6.9, the averages being 6.7 and 6.6, respectively) upper molar tooth row longer and wider (8.2 by 2.3 as opposed to 7.8 by 2.1).

Remarks.—In his revision of the genus *Neotoma*, Goldman (North Amer. Fauna No. 31: 1–124, 14 figs., 8 pls. Oct. 19, 1910) ascribed a range to *Neotoma desertorum* that included that part of eastern Utah along the west side of the Colorado River below its junction with the Green River and on both sides of the Green River above

the junction. That part of the range was largely conjectural since it was based on four specimens from Rangely, Colo., and four from the Henry Mountains (Garfield County?), Utah. Subsequently, the name *Neotoma desertorum* was placed in synonomy with *Neotoma lepida* (see Goldman, Journ. Mamm. **13**(1): 59–67. Feb. 1932). In 1932, Goldman (loc. cit.) named the wood rats from northern Arizona and southern Utah *Neotoma l. monstrabilis*. No mention was made of the animals from Rangely, Colo. In 1942, these were still referred to *N. l. lepida* by Warren (*Mammals of Colorado*). The designation of these animals from northwestern Colorado as *N. l. lepida* is doubtful, since the ranges of *N. l. monstrabilis* and *N. l. sanrafaeli* are interposed between the range of *N. l. lepida* and that area.

Specimens in the collections of the Museum of Zoology, University of Utah, from the vicinity of Escalante, Garfield County, are referable to *N. l. monstrabilis*. Two specimens, nos. 308 and 309, from King's Ranch at the western base of the Henry Mountains in Garfield County, are intergrades between *N. l. monstrabilis* and *N. l. sanrafaeli*. In color they resemble *N. l. monstrabilis;* in the majority of diagnostic cranial characters such as length of palatal bridge, length of nasals, length and width of upper molar tooth row, they are closer to *N. l. sanrafaeli*, to which they are here referred. Thus they represent the southernmost known locality of occurrence of *N. l. sanrafaeli*.

The known range of the subspecies herein described is the same as that ascribed to the kangaroo rat, *Dipodomys ordii sanrafaeli* by Durrant and Setzer (*The distribution and taxonomy of the kangaroo rats (genus* Dipodomys*) of Utah*, Bull. Univ. Utah, biol. ser., **9**(3): 1–39, 2 figs., 4 maps. June 30, 1945).

Specimens examined.—Twenty-eight: All from Utah, distributed as follows: *Emery County:* 7 miles north of Green River, 4,100 feet, 2; pump station, 4 miles north of Green River, 4,100 feet, 6; San Rafael River, 15 miles southwest of Green River, 4,200 feet, 6. *Grand County:* Rock Canyon Corral, 5 miles southeast of Valley City; 4,500 feet, 4; 1 mile east of Highway 160, 6 miles south of Valley City, 4,500 feet [= Rock Canyon Corral], 6. *Wayne County:* Notom, 6,200 feet, 2 *Garfield County:* King's Ranch, 5,000 feet, 2.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

431ST MEETING OF BOARD OF MANAGERS

The 431st meeting of the Board of Managers, held in the Cosmos Club on October 17, 1949, was called to order by the President, F. H. H. ROBERTS, Jr., at 8:10 P.M. Others present were: F. B. SILSBEE, H. A. REHDER, ALAN STONE, F. G. BRICKWEDDE, W. W. DIEHL, F. M. DEFANDORF, W. N. FENTON, C. L. GAZIN, F. E. JOHNSTON, F. D. ROSSINI, J. B. REESIDE, Jr., F. A. WEISS, C. A. BETTS, R. S. DILL, A. O. FOSTER, H. W. HEMPLE, H. G. DORSEY, O. B. FRENCH, F. M. SETZLER, and, by invitation, J. L. SHERESHEFSKY.

The President announced that he had appointed JOHN F. EMBREE to serve as delegate for the Academy at the celebration of the 150th anniversary of the founding of the Connecticut Academy of Arts and Sciences, at Yale University, New Haven, Conn., on November 4, 1949.

The Chairman of the Committee on Grants-in-Aid for Research, J. L. SHERESHEFSKY, indicaten that only one application for a grant had beed received and that he felt that the restrictions controlling the use of the funds available were such that it was difficult for members of the Academy as well as of the constituent societies to qualify. It was suggested that the Chairman confer with officers of the American Association for the Advancement of Science to ascertain whether any changes had been made with regard to these restrictions.

The Committee on Membership submitted the names of two persons for resident membership in the Academy. Nine nominees previously submitted were elected.

The Board announced a request to place JOHN BRIGHT FERGUSON on the retired list effective December 31, 1949.

H. A. REHDER reported that a complete set of the JOURNAL and PROCEEDINGS of the Academy had been ordered by the library of the Eidg. Technische Hochschule of Zurich, Switzerland. He also reported that 60 copies of Friedmann's monograph *The parasitic cuckoos of Africa* had so far been sold, 12 to persons in foreign countries.

The meeting adjourned at 8:52 P.M.

F. M. SETZLER, *Secretary.*

PHILOSOPHICAL SOCIETY

1303d MEETING

The 1303d meeting was held in the auditorium of the Cosmos Club, October 23, 1948, President RAMBERG presiding.

Program: K. K. DARROW, Bell Telephone Laboratories: *Magnetic resonance.*—Magnetic resonance is a phenomenon produced by applying, to any of an enormous variety of substances, a steady strong magnetic field and simultaneously a radiofrequency electromagnetic field. By adjusting the ratio of magnetic field strength to frequency of oscillation, it is often possible to detect a strong and sharp absorption limited to a very narrow range of frequencies (if frequency be the variable) or a very narrow range of field strengths (if strength of magnetic field be the variable). Visualizing the ultimate particles of the substance as tiny bar-magnets, which may be inclined at various angles to the steady field, we may conclude that the radiofrequency field turns these magnets from orientations pointed toward the field-direction into orientations pointed away from the field-direction. The absorption represents the work done against the field when these magnets are turned. The particles to which magnetic resonance is due may be electrons or may be nuclei. The experiments enable the observer to determine the magnetic moments of these particles, to study the rate at which thermal equilibrium is established between nuclei on the one hand and between the environing substance and the magnetic field on the other hand, and to investigate various other problems of physics. (*Author's abstract.*)

1304th MEETING

The 1304th meeting was held in the auditorium of the Cosmos Club, November 6, 1948, President RAMBERG presiding.

Program: M. C. SHELESNYAK, Office of Naval Research: *Human ecology in Arctic regions.*—Increasing interest in the Arctic has revealed an acute absence of any systematic body of scientific information about the basic biological and geophysical conditions. Accumulation and synthesis of systematically collected data are very much needed. Observations during the past century were made chiefly by toil of individuals or small expeditions operating, in general, for short periods with limited technical and financial resources. Many parties have made seasonal studies, but long-term studies are essential to the understanding of Arctic phenomena. Establishment of field stations and laboratories for collection of regional data is vital to Arctic research.

The problems of man in the polar regions are under examination by many and are of special interest to the ecologist, or environmental physiologist. The attention paid these areas, in addition to strategic significance, presents frontiers for investigation of descriptive natural sciences. These regions offer unlimited opportunity for the integration of man's capabilities and limitations with engineering design and development. A continuing concern of man's reactions to the environment and a continuing awareness of the environmental factors confronting them are demanded. (*Author's abstract.*)

1305th MEETING

The 1305th meeting was held in the auditorium of the Cosmos Club, November 20, 1948, President RAMBERG presiding.

Program: R. KRONIG, Technical University of Delft and Visiting Professor at Johns Hopkins University: *The impedance concept in physics and engineering.*—The concept of impedance introduced in the theory of alternating current circuits and very useful in interpreting the electrical behavior of transmission lines is also applicable to other one-dimensional wave phenomena. Thus, just as in the electrical case, the propagation of plane acoustical, optical, or thermal waves in a homogenous medium and of quantum mechanical waves in a region of constant potential, can be described by a pair of first order linear differential equations of the same type for the two quantities characterizing the wave; the quantities being the pressure and velocity in the acoustical, the two field strengths in the optical, the temperature and heat flow in the thermal, and the wave function and its space derivative in the quantum mechanical problem. Remembering that all these quantities are continuous at the boundary between two media and defining their ratio as the acoustical, optical, thermal, or quantum mechanical impedance respectively, we see that the impedance of a medium, composed of different layers bounded by parallel planes, as well as the reflection factor can be computed by the same formulas that apply to a composite cable in the electrical problem. Applications to wall-covering layers in acoustics and to the surface coating of lenses and mirrors in optics are mentioned, and the use of impedance diagrams in the complex plane are illustrated for these fields. The filter-

ing properties of structures periodic in space are mentioned and attention is called to the general relationships between the real and imaginary parts of the propagation constant. (*Author's abstract.*)

1306th MEETING

The 1306th meeting, the 78th annual meeting, was held in the auditorium of the Cosmos Club, December 4, 1948, President RAMBERG presiding.

The report of the Treasurer given by slides showed an income from dues and investments of $1829.45. The current expenses of the Society amounted to $1354.20, leaving a current surplus of $475.25. The current expense per member dropped from $3.75 per member in 1947 to $2.83 per member in 1948. Part of the decrease in expenses during the calendar year was due to the fact that the Joseph Henry Lecturer has not received his honorarium of $100 plus expenses due him when his manuscript is submitted to the Society for publication. The total estimated assets of the Society as of December 1, 1948, were $15,655.67, showing a decrease of $318.75 as compared with December 1, 1947. The Auditing Committee reported that the Treasurer's records and report were in order.

The joint report of the Secretaries showed an active membership of 478.

Program: HORACE M. TRENT, Naval Research Laboratory: *Demonstration of the supersonic reflectoscope.*—Of the many tricks that can be performed with the reflectoscope, the following were selected as being suitable for demonstration to a large audience:

1. THE DETECTION OF FLAWS. The indication obtained from a cylindrical cavity 0.25 by 0.020 inch in a block of aluminum was shown.
2. WAVE GUIDE PROPERTIES OF ULTRASONICS. The indications from two equal-length rods of aluminum, one straight and one S-shaped, were shown.
3. MEASUREMENT OF THIN-PLATE THICKNESS. The series of fish-tail patterns obtained when the operating frequency of the device is varied was demonstrated.
4. INDICATIONS OF INTERNAL DAMPING. The marked difference in the number of multiple echoes obtainable in two rods of armor steel having the same physical dimensions were shown.
5. DYNAMIC CONSTANTS OF PLASTIC MATERIALS. Techniques for establishing the elastic constants of a silicone putty at 1 megacycle/second were demonstrated.
6. ULTRASONICS AS APPLIED TO THE HUMAN BODY. (a) It was shown that human tissue will transmit vibrations of 1 megacycle and that bones are easily located. (b) It was demonstrated that acoustically a gallstone is sufficiently different from tissue to generate a reflection, thus giving promise of a relatively simple method of locating these foreign bodies.

FLOYD A. FIRESTONE, Naval Ordnance Laboratory: *Tricks with the supersonic reflectoscope.*—The supersonic reflectoscope is an instrument normally used for the detection of flaws on the interior of metal parts by sending a short-wave train of ultrasonic waves into the part and then observing the echoes sent back to the sending point. Any echoes arriving at the sending point before the echo from the opposite face of the part are an indication of flaws on the interior.

The waves are sent and received by a thin wafer of quartz placed against the surface of the part with a thin film of oil between. In sending out the waves the quartz is electrically energized with a frequency of about 5,000,000 cycles per second for a time of one-millionth of a second. Reflections of the resulting wave train on striking this same wafer of quartz generate in it a small voltage, which is indicated on a cathode-ray oscilloscope. The sweeping of the oscilloscope spot serves as a time indicating means so that the distance to the reflecting flaw is indicated.

The reflectoscope can be used also for the resonant determination of the thickness of metal parts or for the indication of elastic anisotropy by means of shear waves.

A number of interesting experiments with a reflectoscope supplied by the Naval Research Laboratory were presented by Dr. Horace M. Trent and Mr. Struthers.

1307th MEETING

The 1307th meeting was held in the auditorium of the Cosmos Club, December 18, 1948, President JOHNSTON presiding.

Program: F. D. MURNAGHAN, Johns Hopkins University: *The evolution of the number concept.*—The evolution of the number concept was developed all the way from the counting stage up to and including the quaternion. The intermediate stages discussed were the relative number, the slope number, the real number, and the complex number. The larger part of the paper was devoted

to the discussion of the simpler number properties usually regarded as obvious. A negative number was represented as a relative number or linear one dimensional vector, and the procedure for adding and multiplying such relative numbers was discussd. A method of multiplying numbers was presented that makes it unnecessary to learn multiplication tables beyond the number 5. The subject of fractions was approached from the viewpoint of the slope number concept, and fundamental operations involving such numbers were developed. The more advanced number concepts, such as the complex number and quaternion, were touched on very briefly.

1308th MEETING

The 1308th meeting was held in the auditorium of the Cosmos Club, January 15, 1949, President JOHNSTON presiding.

The retiring president, WALTER RAMBERG, National Bureau of Standards, delivered his presidential address on the subject *Contributions of electricity to mechanics.* This address was published in this JOURNAL **39** (9): 281–294. 1949.

1309th MEETING

The 1309th meeting was held in the auditorium of the Cosmos Club, January 29, 1949, Vice President KRACEK presiding.

Program: HAROLD LYONS, National Bureau of Standards: *Frequency and time standards and the atomic clock.*—The present standard of time is the mean solar day, which is slowly growing longer and fluctuates by about 1 part in 25 million. These and other limitations in astronomical standards make it desirable to look for new invariant and reproducible standards of time and frequency such as those using spectrum lines.

The first atomic clock using the inversion spectrum of ammonia was designed to put frequency and time standards on an invariant basis. It is of the servo type in which a quartz-crystal clock is regulated by the ammonia absorption line through a frequency multiplier chain. Tests showed a constancy of better than 1 part in 20 million.

Three other proposed clocks were described. These consist of two absorption-line or atomic oscillators driving clocks through frequency dividers. The third is a servo clock using atomic beam techniques with a potential accuracy of 1 part in 10 billion. The atomic oscillators are of the feedback type in which regenerative feedback to a microwave amplifier is controlled by an absorption cell. One such oscillator transmits the feedback signal through a magic-tee in which the cell terminates one impedance arm. The other uses a 6-arm wave-guide Wheatstone bridge to control feedback. (*Author's abstract.*)

An informal communication was presented by HARVEY CURTIS, of the National Bureau of Standards, entitled *An annual meeting of forty years ago.* Annual meetings in those days were dress affairs. The attendance in general was much smaller (about 20), and the meetings were held in the east end of the main lounge of the Cosmos Club in probably the same chairs that are now there. Cigars were provided for all members by the Society, and the annual meeting was the only meeting during the year at which refreshments were served. The president of the Society at that time was Simon Newcomb, the eminent astronomer. The officers of the Society were elected by ballot and frequently more than one ballot was necessary. About half the membership served on the General Committee, which handled the business affairs of the Society. (*Secretary's abstract.*)

1310th MEETING

The 1310th meeting was held in the auditorium of the Cosmos Club, February 12, 1949, Vice President KRACEK presiding.

Program: J. R. DUNNING, Columbia University: *High-energy accelerator progress.*—High-energy accelerators should play a steadily more important role in studying nuclear processes, nuclear forces, and the nature of "fundamental" particles. Progress in the design of accelerators was discussed for electrostatic generators, conventional cyclotrons, synchrocyclotrons, linear accelerators, betatrons, electron synchrotrons, and proton synchrotrons. The limitations of the various types were pointed out, and it was concluded that whereas the synchrocyclotron and electron synchrotron are satisfactory in the 500 MEV to possibly 1 BEV region, the proton synchrotron appears most practical in the 1 to 10 BEV region. The possibilities of future research with these nuclear machines were discussed. (*Author's abstract.*)

1311th MEETING

The 1311th meeting was held in the auditorium of the Cosmos Club, February 26, 1949, Vice President CHENEY presiding.

Program: L. MARTON, National Bureau of Standards: *Observations of electromagnetic fields.*—For many years a very convenient method, called

the Schlieren method, has been widely used in light optics for the purpose of observing small changes in the refractive index of more or less homogeneous media. Such a method can be easily translated in terms of electron optics by using electron beams instead of light rays and the variations of the electromagnetic index of refraction instead of that of the index for light. The consequences are that by means of a systematic application of this well-known method to electron optics we are able to measure electromagnetic fields that may otherwise be partially or even completely inaccessible to any other type of measurement.

The simplest application of this new electron optical method consists of producing a reduced-size image of an electron source by means of a magnetic or electrostatic electron lens and of catching all direct rays by a suitably placed stop. If there are no fields of force between the source and the lens, the space beyond the stop will be completely dark. If, however, there is a variation of the electromagnetic index of refraction somewhere between the source and the lens, in a conjugate plan to such a disturbance, a dark field image will appear.

The essential features of the new method have been demonstrated and examined by using a magnetized steel wire (as used for recording purposes) as a convenient test object. The patterns obtained can be compared readily to colloidal powder patterns obtained on the same material. They show that, in a qualitative manner, the agreement is excellent. For quantitative purposes, however, the dark field method is not quite satisfactory, and that is why a bright field method, more suitable for quantitative investigations, has been developed. This bright field method consists in its simplest form of an electron source and an electron lens forming a reduced sized image of the source. At a convenient distance behind the image of the source a fine wire mesh is placed. The image of the source, acting as a virtual source of very small size, produces an enlarged shadow image of the wire mesh in the image plane. In the absence of any fields in the object space the image of the mesh is undistorted. In the presence of fields, however, the picture of the mesh will be distorted and the amount of distortion is a measure of the strength of these fields. Experiments, carried out mostly on the same magnetized-wire material as mentioned before, have shown that the method is eminently suited to quantitative investigation.

This new method for mapping of electromagnetic fields can be applied to a very wide variety of phenomena, such as space charge fields, fields of standing electromagnetic waves, and fields resulting from contact potentials. As a demonstration of the usefulness of this method slides depicting fields of individual ferromagnetic domains were shown. (*Author's abstract.*)

1312th MEETING

The 1312th meeting was held in the auditorium of the Cosmos Club, March 12, 1949, Vice President KRACEK presiding.

Program: E. TELLER, University of Chicago: *The origin of cosmic rays.*—The presence of heavy particles in cosmic rays makes it plausible that cosmic radiation is generated by the acceleration of charged particles in extended electromagnetic fields. The energy density of cosmic rays (3×10^{-10} Mc^2/cm^3) would lead to very great total amounts of energy if one assumes that cosmic radiation extends throughout intergalactic or throughout interstellar space. This would require very efficient methods of cosmic ray production. Fermi has recently proposed a most ingenious mechanism that may furnish the required energy to the cosmic radiation. According to this proposal, cosmic radiation constitutes an essential component in the energy distribution within the galaxy, and the mechanism regulating the intensity of cosmic rays is based upon the balancing of the various forms of energy. Difficulties connected with the presence in cosmic radiation of nuclei carrying more than one charge give rise to some doubt whether or not Fermi's proposal is the correct explanation of cosmic rays. It is therefore of interest to investigate the possibility that cosmic rays are generated in the vicinity of the sun and are confined to the solar system by extended magnetic fields. The strength of these fields is estimated to be 10^{-5} Gauss. According to this picture, cosmic rays circulate in the neighborhood of the planetary system for thousands of years during which time the radiation becomes isotropic. The electron component of the radiation is eliminated by collisions with solar light quanta. (*Author's abstract.*)

1313th MEETING

The 1313th meeting was held in the auditorium of the Cosmos Club, March 26, 1949, President JOHNSTON presiding.

Program: H. F. STIMSON, National Bureau of Standards: *The international temperature scale.*—

The platinum resistance thermometer was developed during the last part of the nineteenth century and the beginning of the twentieth. With resistance thermometers it became possible to determine temperatures more precisely than with a gas thermometer. The experimental difficulties inherent in the measurement of temperature on the thermodynamic scale led to the adoption, in 1927, of a practical scale which was designated as the international temperature scale. Provisions were made for revising this scale, but it was not until 1948 that a revision was adopted.

The international temperature scale of 1948 is based upon six fixed and reproducible equilibrium temperatures to which numerical values have been assigned and upon specified interpolation formulas relating temperature to the indications of specified measuring instruments. It is designed to conform as nearly as practicable to the thermodynamic Celsius (centigrade) scale as now known, while incorporating certain refinements based on experience to make the scale more uniform and reproducible than its predecessor. A new value for the temperature of the silver point and the use of Planck's law with a new value for the radiation constant c_2 are the only changes which produce significant effects on numerical values assigned to temperatures. (*Author's abstract.*)

1314th MEETING

The 1314th meeting was held in the auditorium of the Cosmos Club, April 9, 1949, President JOHNSTON presiding.

Program: JOHN A. WHEELER, Princeton University: *Mesons, the elusive elementary particles.*—The study of the nuclear transformations produced in the upper atmosphere by the high-energy hydrogen nuclei incident upon the earth from outer space has been and continues to be a fruitful means to learn about the properties and genetic interrelations of the elementary particles. That three-fourths of the cosmic radiation arriving at sea level is made up of mesons was discovered by Carl Anderson in 1938. These particles have a mass approximately 214 times the mass of the electron, or about one-ninth the mass of a proton. In 1947 Powell and his collaborators at Bristol discovered another heavier meson of mass now believed to be approximately 286 times the mass of the electron, a particle with life only 10^{-8} sec, which serves as the progenitor of the ordinary sea-level variety of meson. How both kinds of mesons disappear via radioactive decay or nuclear reactions was described. From analysis of these transformations it has turned out that there exists a remarkable and so far unexplained regularity—an approximate identity in the values of the so-called coupling constants required to account for (a) the radioactive decay of the sea-level kind of meson into an electron and two neutral particles, presumably neutrinos; (b) the radioactive decay of a nuclear neutron into a proton, an electron and a neutrino, and (c) the reaction of a sea-level meson with a nuclear proton to form a neutron and a nuclear particle, presumably a neutrino. Finally a summary was made of the experimental evidence recently obtained by Dr. W. Y. Chang, of Princeton, for the emission of characteristic gamma radiation with energies in a range 1, to 4 Mev by mesons jumping from one Bohr orbit to another in a field of force of an atomic nucleus. (*Author's abstract.*)

1315th MEETING

The 1315th meeting was held in the auditorium of the Cosmos Club, April 23, 1949, PRESIDENT JOHNSTON presiding.

Program: BRUNO ROSSI, Massachusetts Institute of Technology: *Cosmic rays.*—Cosmic rays are of great interest both to the astronomer and to the physicist. From the point of view of the physicist, cosmic rays may be regarded as a source of very high energy particles. Cosmic rays contain all kinds of known elementary particles, some of which were actually discovered during the study of cosmic ray phenomena. Elementary particles interact with matter through forces of electromagnetic character and of nuclear character. The general laws of quantum electrodynamics appear adequate to describe electromagnetic interactions. No general theory of nuclear interactions exists so far. Experiments have shown that nuclear interactions in cosmic ray phenomena are mainly due to high energy protons and neutrons. They have also shown that nuclear interactions give rise to secondary nucleons as well as to mesons and to electronic radiation. Much more experimental work is necessary before all the details of nuclear interactions of high energy particles are completely understood. What has been learned so far, however, is sufficient to clarify the relationship between the primary cosmic radiation, believed to consist mainly of high energy protons, and the radiation observed under thick layers of air, which is known to consist mainly of mesons and electrons. (*Author's abstract.*)

1316th MEETING

The 1316th meeting was held in the auditorium of the Cosmos Club, May 7, 1949, President JOHNSTON presiding.

Program: HENRY MARGENAU, Yale University: *Causality in classical and modern physics.*—Common speech uses the words "cause and effect" in the sense of partial cause and partial effect. As such they may mean things or events. History has progressed toward a more refined definition of these terms; in this refined version they mean states of certain systems.

Upon discussion and analysis, LaPlace's classical formulation of the causal principle was found defective, requiring supplementation in the form of restrictions upon his world formula. It was shown that this formula may not contain the time variable explicitly. Consideration of the changes that have taken place in the description of states as a result of quantum mechanics leads to the conclusion that modern physics is still a causal discipline, provided the states of its systems are correctly defined. In conclusion, recent attempts to demonstrate human freedom on the basis of quantum mechanics were viewed and were shown to be unsuccessful. (*Author's abstract.*)

1317th MEETING

The 1317th meeting was the occasion of the Eighteenth Joseph Henry Lecture and was held in the auditorium of the Cosmos Club, May 14, 1949, President JOHNSTON presiding.

Program: MAURICE EWING, Columbia University: *Basement rocks beneath the ocean.* This address will be published in full in this JOURNAL.

1318th MEETING

The 1318th meeting was held in the auditorium of the Cosmos Club, May 21, 1949, President JOHNSTON presiding.

Program: R. J. SEEGER, Naval Ordnance Laboratory: *On research in aerophysics.*—Throughout the history of science fluid dynamics has been concerned largely with ideal fluids with or without viscosity. In recent years it has been primarily a domain of mathematics, which has concerned itself with solving the basic partial differential equations for particular boundary conditions. Physical phenomena such as turbulence have long been regarded as incomprehensible. Nowadays, however, as faster and faster aircraft have come into existence, neglected physical factors such as compressibility (including shock-wave phenomena with its attenuating shock waves, their interactions with boundary layers, and the associated thermal conduction) have presented experiential questions that can no longer be ignored. Moreover, the achievement of high altitudes with their peculiar problems of rarefied gases has invoked renewed interest in kinetic theory both for equilibrium and nonequilibrium states. The term aerophysics has been applied in recent years to this area of investigation.

The meaning of high-speed flow in this connection is one of relative speed rather than of absolute speed. Thus the maximum speed attainable for expansion under atmospheric condition is 2,770 ft/sec, whereas the Mach number in this case could potentially become infinite (assuming no change in the extrapolated physical equation state). The speaker's remarks concerned the aeroballistic research facilities at White Oak, Md., which are prosecuting a vigorous program involving such high-speed flows. A discussion of the facilities included the two 40 by 40 cm supersonic wind tunnels and the 18 by 18 cm spersonic wind tunnel, which are now operating up to Mach numbers of 5. In addition, four 12 by 12 cm supersonic wind tunnels, which are now being constructed, were described; namely, one for internal aerodynamics, one for aerophysics, one for heat-transfer, and one for hypersonics.

A historical example emphasized the difficulty of correlating scaled wind-tunnel data with free-flight experiments involving unknown phenomena such as turbulence. Information was given about the NOL pressurized ballistics range, which will permit investigations of Reynolds' number effects under variable pressure.

Finally, the shock tube was cited as an auxiliary aeroballistics apparatus that can be utilized for precision experiments on non-linear phenomena. For example, a study of the refraction of gaseous shock waves presents challenging predictions for experiential observations: namely, (1) the limit of regular refraction to certain angles of incidence beyond which new phenomena must appear, (2) the nonexistence of critical reflection for finite shock waves, and (3) the existence of either reflected shock waves or of reflected rare faction waves from the boundary of two gaseous media, depending upon the strength and the direction of the incident wave (hence the possibility of a transition angle at which no reflected wave at all exists). (*Author's abstract.*)

R. SMELT, Naval Ordnance Laboratory: *Problems of hypersonic flow.*—The aerodynamicist realizes that outside the range of his present equipment to study supersoic flow there are other

regimes of flow which are currently described as "hypersonic." The term hypersonic is rather indefinite, for it covers a large number of distinct phenomena. For example, one definition of hypersonic flow describes it as flow at Mach numbers exceeding those where simple linearized supersonic theory is applicable. This can be shown to be related to pressure conditions approaching absolute vacuum at some point in the flow.

Other phenomena that become apparent at very high speeds result from the fact that air is an imperfect gas. To some extent the adoption of a new equation of state can describe these effects.

Experimental methods of achieving hypersonic flow conditions include the hypersonic wind tunnel, expanding air from a high pressure into a vacuum, and the hypersonic range, in which projectiles are fired through still air at very high speeds. Problems of the hypersonic tunnel result from the approach to liquefaction temperatures in the air after expansion. The hypersonic range, on the other hand, produces problems of dissociation and even ionization in consequence of the high air temperatures produced around a projectile. (*Author's abstract.*)

ARCHIE I. MAHAN, *Recording Secretary.*

Obituary

RAYMOND MCGEARY HANN, chief of the laboratory of chemistry at the National Institutes of Health, died early in the morning of April 30, 1949, at the U. S. Marine Hospital in Baltimore, Md., and was buried at the Arlington National Cemetery. His death was caused by a malignant growth in the pharynx which had bothered him since 1944. During these last five years, in spite of the fact that his health was growing progressively worse, his spirits remained high and he continued with his research and writing.

Dr. Hann was born in Washington, D. C., on January 28, 1900. After graduation from high school in 1918 he entered the United States Army, but after two months of service the war was over, and he was given his release. He then started work as a scientific aide at the U. S. Department of Agriculture and at the same time entered the George Washington University evening school to study chemistry. In 1925 he received his B.S. degree. His research work with the Department of Agriculture while attending school gave him 15 scientific publications before he received this degree. In 1926 he received his M.S. degree from the same institution. In 1928 he received his Ph.D. degree in chemistry from the Johns Hopkins University in Baltimore.

The following year after graduation he held a fellowship at the Mellon Institute for Industrial Research in Pittsburgh. He then entered the National Institute of Health as a research chemist, specializing in the organic chemistry and synthesis of sugars. During his 20 years at this institution he published more than 120 research papers, most of which are published in the Journal of the American Chemical Society.

He joined the American Chemical Society in 1922 and was very active in the Washington local section, being its treasurer in 1936 and 1937, its secretary in 1938 and 1939, and its president in 1940. He was a Vice President of the Washington Academy of Sciences in 1940. He was also an active member of the Alpha Chi Sigma Professional Chemical Fraternity.

In 1944 the Chemical Society of Washington presented him with the Hillebrand Award, which is given annually to a Washington member for noteworthy contribution to chemistry. Dr. Hann's award was based on his work in sugar chemistry, "investigations leading to a number of anhydro sugars culminating in the definitive synthesis of lactose and cellobiose; and the application of copper sulfate oxidation of sugar phenylosazones to form osatriazoles, compounds which promise to find wide use in the characterization of sugars."

At the request of the division of sugar chemistry and technology of the American Chemical Society, he and a collaborator collected and edited for publication all the works of Dr. C. S. Hudson, which appeared in two volumes in 1948.

Dr. Hann's chief hobby was boating, which he took very seriously. Before the last war he was the owner of a 34-foot cabin cruiser, on which he and his friends spent many delightful hours. He was a member of the Corinthian Yacht Club. He was also a member of the Potomac River Power Squadron, a boating organization, in which he was very active, especially in the studying and teaching of seamanship, piloting, and celestial navigation.

Dr. Hann was married in 1931 to Miss Rhonda Nebeker. They had one daughter, Carol, who was eight years of age at the time of her father's death.

NORMAN BEKKEDAHL.

INDEX TO VOLUME 39

An asterisk (*) denotes the abstract of a paper presented before the Academy or an affiliated society.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Anthropological Society of Washington. 177.
Geological Society of Washington. 105.
Philosophical Society of Washington. 420.
Washington Academy of Sciences. 47, 82, 102, 174, 206, 279, 343, 380, 419.

AUTHOR INDEX

ABLEITER, J. KENNETH. Alfred Paul Dachnowski-Stokes (obituary). 348.

ADAMS, LEASON H. Richard Chace Tolman (obituary). 280.

AMSDEN, THOMAS W. Two new genera of brachiopods from the Henryhouse formation (Silurian) of Oklahoma. 202.

ANDREWS, ALFRED C. The codfishes of the Greeks and Romans. 1.

BAKER, EDWARD W. Pomerantziidae, a new family of prostigmatic mites. 269.

BANGHAM, RALPH V. See VAN CLEAVE, H. J. 398.

BARKSDALE, WILLIAM L. See BLACK, R. F. 107.

BAYER, FREDERICK M. Chalcogorgiinae, a new subfamily of Chrysogorgiidae (Coelenterata: Alcyonaria), and a description of *Chalcogorgia pellucida*, new genus and new species, from the Straits of Florida. 237.

BECK, HORACE P. The animal that cannot lie down. 294.

BEHRE, C. H., Jr. *Structural control of the European lead-zinc deposits of the "Mississippi Valley" type. 110.

BEKKEDAHL, NORMAN. Raymond McGeary Hann (obituary). 426.

BETTS, C. A. Samuel Henry McCrory (obituary). 180.

BISHOPP, F. C. Edward Rhodes Stitt (obituary). 381.

BLACK, ROBERT F., and BARKSDALE, WILLIAM L. * Oriented lakes of northern Alaska, 107.

BLACKWELDER, RICHARD E. An adventure in biblio-chronology. 301.

BLAKE, DORIS H. Notes on some West Indian Chrysomelidae. 367.

BROWN, ROLAND W. Nelson Horatio Darton (obituary). 114.

———. Pliocene plants from Cache Valley, Utah. 224.

BROWN, WALTER C., and MYERS, GEORGE S. A new frog of the genus *Batrachylodes* from the Solomon Islands. 379.

CHAMBERLIN, RALPH V. On some western millipeds of the order Spirobolida. 163.

———. Some millipeds of the families Polydesmidae and Xystodesmidae. 94.

CLARK, AUSTIN H. Echinoderms from the mid-Atlantic dredged by the *Atlantis* in the summer of 1948. 371.

———. Some littoral sea-urchins from the Philippines. 271.

CREAMER, A. S. See HUNT, CHARLES B. 120.

CURTIS, HARVEY L. * An annual meeting [Philosophical Society] of forty years ago. 422.

———. Establishment of graduate study courses at the National Bureau of Standards. 351.

CURTIS, KARL P., and WILLEY, GORDON R. A Veraguas grave. 17.

DARROW, K. K. * Magnetic resonance. 420.

DEIGNAN, H. G. Races of *Pycnonotus cafer* (Linnaeus) and *P. aurigaster* (Vieillot) in the Indo-Chinese Subregion. 273.

DOBROVOLNY, ERNEST. * Geology applied to highway design and construction. 108.

DORN, HAROLD F. Morbidity from cancer. 117.

DORSEY, N. ERNEST. A fallacy regarding integers. 49.

DUNCAN, HELEN. Genotypes of some Paleozoic Bryozoa. 122.

DUNNING, J. R. * High-energy accelerator progress. 422.

EMBREE, JOHN. A visit to Laos, French Indochina. 149.

EWERS, JOHN C. The last bison drives of the Blackfoot Indians. 355.

EWING, H. E. The origin and classification of the trombiculid mites, or Trombiculidae. 229.

FAHEY, JOSEPH J. See HUNT, CHARLES B. 120.

FIRESTONE, FLOYD A. * Tricks with the supersonic reflectoscope. 421.

FISCHER, R. P. * Origin of the Colorado Plateau vanadium deposits. 109.

GAHAN, A. B. The status of the genus *Mymar* Curtis (Hymenoptera: Mymaridae). 204.

GAZIN, C. LEWIS. A leptictid insectivore from the middle Eocene Bridger formation of Wyoming. 220.

GIDDINGS, J. L., Jr. Early flint horizons on the north Bering Sea coast. 85.

GOLDMAN, MARCUS I. * Bauxitization—a tropical disease. 107.

GURNEY, ASHLEY B. Distributional and synonymic notes on psocids common to Europe and North America, with remarks on the distribution of Holarctic insects (Corrodentia). 56.

GUYTON, WILLIAM F. * Industrial use of ground water in the United States. 105.

HARRY, ROBERT R. A new species of goby and new records of fishes from the Solomon Islands. 140.

HERMANN, FREDERICK J. Studies in *Lonchocarpus* and related genera, V: New species from Middle America and the *Lonchocarpus guatemalensis* complex. 306.

HOFFMEISTER, DONALD F. A new name for the meadow mouse *Microtus roberti occidentalis* Turov. 205.

HUNT, CHARLES B.; CREAMER, A. S.; and FAHEY, JOSEPH J. A newly discovered type of clay deposit in Utah. 120.

HURLBUT, HERBERT S. See KNIGHT, K. L. 20.

JORDAN, GEORGE F. Joseph Alfred Ambler (obituary). 115.

KELSON, KEITH R. Two new wood rats from eastern Utah. 417.

KNIGHT, KENNETH L., and HURLBUT, HERBERT S. The mosquitoes of Ponape Island, eastern Carolines. 20.

KRONIG, R. * The impedance concept in physics and engineering. 420.

LANGEBARTEL, DAVE A. See SMITH, H. M. 409.

LEWIS, G. EDWARD. *El Sangay, and some other volcanoes of Ecuador. 105.

LITTLE, ELBERT L. Nomina conservanda proposals for families of seed plants. 323.

LOEBLICH, ALFRED R., Jr., and TAPPAN, HELEN. New Kansas Lower Cretaceous Foraminifera. 90.

LOOMIS, H. F. New millipeds of the spiroboloid genus *Watichelus* from the Pacific coast. 241.

LOVERING, T. S. William Harvey Emmons (obituary). 215.

LYONS, HAROLD. * Frequency and time standards and the atomic clock. 422.

MARGENAU, HENRY. *Causality in classical and modern physics. 425.

MARTON, L. * Observations of electromagnetic fields. 422.

McVAUGH, ROGERS. Seven new species of Lobelioideae (Campanulaceae). 157.

MILLER, CARL F. An analysis of several Deptford-like pottery types found at a village site north of Moore's Creek, Cape Fear River, North Carolina. 317.

MITTLEMAN, M. B. The validity of relative head width in defining the races of *Ambystoma macrodactylum*. 43.

MOFFIT, FRED H. Philip Sidney Smith (obituary). 315.

MORTON, C. V. William Ralph Maxon (obituary). 247.

MURNAGHAN, F. D. * The evolution of the number concept. 421.

MYERS, GEORGE S. See BROWN, WALTER C. 379.

PHELPS, WILLIAM H., Jr. See WETMORE, A. 377.

RAMBERG, WALTER. Contributions of electricity to mechanics. 281.

RAND, FREDERICK V. Albert Fred Woods (obituary). 313.

RAY, LOUIS L. François Emile Matthes (obituary). 146.

REEDER, CHARLOTTE GOODDING. *Muhlenbergia minutissima* (Steud.) Swallen and its allies. 363.

ROSS, CLARENCE S. Charles Whitman Cross (obituary). 347.

ROSS, C. P. * The Belt problem. 111.

ROSS, HERBERT H. The caddisfly genus *Neothremma* Banks (Trichoptera: Limnephilidae). 92.

ROSSI, BRUNO. * Cosmic rays. 424.

ROSSINI, FREDERICK D. An excursion in chemical thermodynamics. 249.

SAUNDERS, HAROLD E. Dwight F. Windenburg (obituary). 247.

SAYRE, A. NELSON. Oscar Edward Meinzer (obituary). 147.

SEEGER, R. J. * On research in aerophysics. 425.

SCHULTZ, LEONARD P., and WOODS, LOREN P. Keys to the genera of echelid eels and the species of *Muraenichthys* of the Pacific, with two new species. 169.

SHELESNYAK, M. C. *Human ecology in Arctic regions. 420.

SHOEMAKER, CLARENCE R. The amphipod genus *Corophium* on the west coast of America. 66.

———. Three new species and one new variety of amphipods from the Bay of Fundy. 389.

SMELT, R. *Problems of hypersonic flow. 425.

SMITH, HOBART M. Miscellaneous notes on Mexican lizards. 34.

——— and LANGEBARTEL, DAVE A. Notes on a collection of reptiles and amphibians from the Isthmus of Tehuantepec, Oaxaca. 409.

SMITH, PHILIP S. Stephen Reid Capps (obituary). 179.

SNYDERMAN, GEORGE S. The case of Daniel P.: An example of Seneca healing. 217.

SOKOLOFF, V. P. *Engineering map units in Fairfax quadrangle, Virginia. 109.

STIMSON, H. F. *The international temperature scale. 423.

STOSE, GEORGE W. Bailey Willis (obituary). 346.

TAPPAN, HELEN. See LOEBLICH, A. R., Jr. 90.

TELLER, E. * The origin of cosmic rays. 423.

TRENT, HORACE M. * Demonstration of the supersonic reflectoscope. 421.

TRESSLER, WILLIS L. Marine Ostracoda from Tortugas, Florida. 335.

VAN CLEAVE, HARLEY J., and BANGHAM, RALPH V. Four new species of the acanthocephalan family Neoechinorhynchidae from fresh-water fishes of North America, one representing a new genus. 398.

VENNING, FRANK D. Cortical tracheids in the African cherry oranges (*Citropsis* species, Rutaceae: Aurantioideae). 383.

VOKES, H. E. The hinge and marginal pectinations of *Nuculoidea opima* (Hall), type of *Nuculoidea* Williams and Breger. 361.

WETMORE, ALEXANDER. A note on *Corythus splendens* Brehm. 245.

———. Geographical variation in the American redstart (*Setophaga ruticilla*). 137.

——— and PHELPS, WILLIAM H., Jr. A new race of bird of the genus *Spodiornis* from Venezuela. 377.

WHEELER, JOHN A. * Mesons, the elusive elementary particles. 424.

WHITE, THEODORE E. The endocrine glands and evolution, No. 2: The appearance of large amounts of cement on the teeth of horses. 329.

WILLEY, GORDON R. See CURTIS, KARL P. 17.

WOODS, LOREN P. See SCHULTZ, LEONARD P. 169.

WORMAN, EUGENE C., Jr. The "Neolithic" problem in the prehistory of India. 181.

SUBJECT INDEX

Anthropology. The last bison drives of the Blackfoot Indians. JOHN C. EWERS. 355.

Archeology. An analysis of several Deptford-like pottery types found at a village site north of Moore's Creek, Cape Fear River, North Carolina. CARL F. MILLER. 317.

A Veraguas grave. KARL P. CURTIS and GORDON R. WILLEY. 17.

Early flint horizons on the north Bering Sea coast. J. L. GIDDINGS, Jr. 85.

The "Neolithic" problem in the prehistory of India. EUGENE C. WORMAN, Jr. 181.

Biology. An adventure in biblio-chronology. RICHARD E. BLACKWELDER. 301.

Botany. Cortical tracheids in the African cherry oranges (*Citropsis* species, Rutaceae: Aurantioideae). FRANK D. VENNING. 383.

Muhlenbergia minutissima (Steud.) Swallen and its allies. CHARLOTTE GOODDING REEDER. 363.

Nomina conservanda proposals for families of seed plants. ELBERT L. LITTLE, Jr. 323.

Seven new species of Lobelioideae (Campanulaceae). ROGERS MCVAUGH. 157.

Studies in *Lonchocarpus* and related genera, V: New species from Middle America and the *Lonchocarpus guatemalensis* complex. FREDERICK J. HERMANN. 306.

Ecology. * Human ecology in Arctic regions. M. C. SHELESNYAK. 420.

Entomology. Distributional and synonymic notes on psocids common to Europe and North America, with remarks on the distribution of Holarctic insects (Corrodentia). ASHLEY B. GURNEY. 56.

Notes on some West Indian Chrysomelidae. DORIS H. BLAKE. 367.

Pomerantziidae, a new family of prostigmatic mites. EDWARD W. BAKER. 269.

The caddisfly genus *Neothremma* Banks (Trichoptera: Limnephilidae). HERBERT H. ROSS.

The mosquitoes of Ponape Island, eastern Carolines. KENNETH L. KNIGHT and HERBERT S. HURLBUT. 20.

The origin and classification of the trombiculid mites, or Trombiculidae. H. E. EWING. 229.

The status of the genus *Mymar* Curtis (Hymenoptera: Mymaridae). A. B. GAHAN. 204.

Ethnology. A visit to Laos, French Indochina. JOHN EMBREE. 149.

The animal that cannot lie down. HORACE P. BECK. 294.

The case of Daniel P.: An example of Seneca healing. GEORGE S. SNYDERMAN. 217.

Geology. A newly discovered type of clay deposit in Utah. CHARLES B. HUNT, A. S. CREAMER, and JOSEPH J. FAHEY. 120.

* Bauxitization—a tropical disease. MARCUS I. GOLDMAN. 107.

* El Sangay, and some other volcanoes of Ecuador. G. EDWARD LEWIS. 105.

* Engineering map units in Fairfax quadrangle, Virginia. V. P. SOKOLOFF. 109.

* Geology applied to highway design and construction. ERNEST DOBROVOLNY. 108.

* Industrial use of ground water in the United States. WILLIAM F. GUYTON. 105.

* Oriented lakes of northern Alaska. ROBERT F. BLACK and WILLIAM L. BARKSDALE. 107.

* Origin of the Colorado Plateau vanadium deposits. R. P. FISCHER. 109.

* Structural control of the European lead-zinc deposits of the "Mississippi Valley" type. C. H. BEHRE, Jr. 110.

*The Belt problem. C. P. ROSS. 111.

Herpetology. A new frog of the genus *Batrachylodes* from the Solomon Islands. WALTER C. BROWN and GEORGE S. MYERS. 379.

Miscellaneous notes on Mexican lizards. HOBART M. SMITH. 34.

Notes on a collection of reptiles and amphibians from the Isthmus of Tehuantepec, Oaxaca. HOBART M. SMITH and DAVE A. LAGEBARTEL. 409.

The validity of relative head width in defining the races of *Ambystoma macrodactylum.* M. B. MITTLEMAN. 43.

History of science. * An annual meeting [Philosophical Society] of forty years ago. HARVEY CURTIS. 422.

Ichthyology. A new species of goby and new records of fishes from the Solomon Islands. ROBERT R. HARRY. 140.

Keys to the genera of echelid eels and the species of *Muraenichthys* of the Pacific, with two new species. LEONARD P. SCHULTZ and LOREN P. WOODS. 169.

Mammology. A new name for the meadow mouse *Microtus roberti occidentalis* Turov. DONALD F. HOFFMEISTER. 205.

Two new wood rats from eastern Utah. KEITH R. KELSON. 417.

Mathematics. A fallacy regarding integers. N. ERNEST DORSEY. 49.

* The evolution of the number concept. F. D. MURNAGHAN. 421.

Medicine. Morbidity from cancer. HAROLD F. DORN. 117.

Natural history. The codfishes of the Greeks and Romans. ALFRED C. ANDREWS. 1.

Obituaries.

JOSEPH ALFRED AMBLER, 115.
ERNEST CLAYTON ANDREWS. 214.
STEPHEN REID CAPPS. 179.
CHARLES WHITMAN CROSS. 347.
NELSON HORATIO DARTON. 114.
WILLIAM HENRY EMMONS. 215.
ALFRED PAUL DACHNOWSKI-STOKES. 348.
RAYMOND MCGEARY HANN. 426.
HORACE TERHUNE HERRICK. 114.
FRANÇOIS EMILE MATTHES. 146.

Obituaries—Cont.
WILLIAM RALPH MAXON. 247.
SAMUEL HENRY MCCRORY. 180.
OSCAR EDWARD MEINZER. 147.
PHILIP SIDNEY SMITH. 315.
EDWARD RHODES STITT. 381.
RICHARD CHACE TOLMAN. 280.
BAILEY WILLIS. 346.
DWIGHT F. WINDENBURG. 247.
ALFRED FRED WOODS. 313.
Ornithology. A new race of bird of the genus *Spodiornis* from Venezuela. ALEXANDER WETMORE and WILLIAM H. PHELPS, JR. 377.
A note on *Corythus splendens* Brehm. ALEXANDER WETMORE. 245.
Geographical variation in the American redstart (*Setophaga ruticilla*). ALEXANDER WETMORE. 137.
Races of *Pycnonotus cafer* (Linnaeus) and *P. aurigaster* (Vieillot) in the Indo-Chinese Subregion. H. G. DEIGNAN. 273.
Paleobotany. Pliocene plants from Cache Valley, Utah. ROLAND W. BROWN. 224.
Paleontology. A leptictid insectivore from the middle Eocene Bridger formation of Wyoming. C. LEWIS GAZIN. 220.
Genotypes of some Paleozoic Bryozoa. HELEN DUNCAN. 122.
New Kansas Lower Cretaceous Foraminifera. ALFRED R. LOEBLICH, JR., and HELEN TAPPAN. 90.
The hinge and marginal pectinations of *Nuculoidea opima* (Hall), type of *Nuculoidea* Williams and Breger. H. E. VOKES. 361.
Two new genera of brachiopods from the Henryhouse formation (Silurian) of Oklahoma. THOMAS W. AMSDEN. 202.
Physical chemistry. An excursion in chemical thermodynamics. FREDERICK D. ROSSINI. 249.
Physics. * Causality in classical and modern physics. HENRY MARGENAU. 425.
Contributions of electricity to mechanics. WALTER RAMBERG. 281.
* Cosmic rays. BRUNO ROSSI. 424.
* Demonstration of the supersonic reflectoscope. HORACE M. TRENT. 421.
* Frequency and time standards and the atomic clock. HAROLD LYONS. 422.
* High-energy accelerator progress. J. R. DUNNING. 422.
* Magnetic resonance. K. K. DARROW. 420.
* Mesons, the elusive elementary particles. JOHN A. WHEELER. 424.
* Observations of electromagnetic fields. L. MARTON. 422.
* On research in aerophysics. R. J. SEEGER. 425.
* Problems of hypersonic flow. R. SMELT. 425.
* The impedance concept in physics and engineering. R. KRONIG. 420.
* The international temperature scale. H. F. STIMSON. 423.
* The origin of cosmic rays. E. TELLER. 423.
* Tricks with the supersonic reflectoscope. FLOYD A. FIRESTONE. 421.
Physiology. The endocrine glands and evolution, No. 2: The appearance of large amounts of cement on the teeth of horses. THEODORE E. WHITE. 329.
Science education. Establishment of graduate study courses at the National Bureau of Standards. HARVEY L. CURTIS. 351.
Zoology. Chalcogorgiinae, a new subfamily of Chrysogorgiidae (Coelenterata: Alcyonaria), and a description of *Chalcogorgia pellucida*, new genus and new species, from the Straits of Florida. FREDERICK M. BAYER. 237.
Echinoderms from the mid-Atlantic dredged by the *Atlantis* in the summer of 1948. AUSTIN H. CLARK. 371.
Four new species of the acanthocephalan family Neoechinorhynchidae from freshwater fishes of North America, one representing a new genus. HARLEY J. VAN CLEAVE and RALPH V. BANGHAM. 398.
Marine Ostracoda from Tortugas, Florida. WILLIS L. TRESSLER. 335.
New millipeds of the spiroboloid genus *Watichelus* from the Pacific coast. H. F. LOOMIS. 241.
On some western millipeds of the order Spirobolida. RALPH V. CHAMBERLIN. 163.
Some littoral sea-urchins from the Philippines. AUSTIN H. CLARK. 271.
Some millipeds of the families Polydesmidae and Xystodesmidae. RALPH V. CHAMBERLIN. 94.
The amphipod genus *Corophium* on the west coast of America. CLARENCE R. SHOEMAKER. 66.
Three new species and one new variety of amphipods from the Bay of Fundy. CLARENCE R. SHOEMAKER. 389.